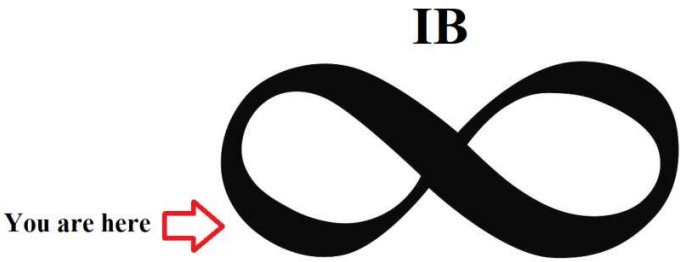
IB Physics SL Worksheets
1.1-8.2



I created these worksheets to introduce both students and teachers to just some of the great physics resources on the internet. Please feel free to distribute this pdf freely.

I suggest all IB physics students to go to a print shop, have this pdf printed and bound, and use it as a workbook.

Comments? Questions? Suggestions? Please feel free to contact me!

admin@gophysicsgo.com

Best way to learn physics
Matt Anderson
https://www.youtube.com/watch?v=4oW3tWAylpw

Marty Lobdell - Study Less Study Smart
PierceCollegeDist11
https://www.youtube.com/watch?v=IlU-zDU6aQ0

Scientifically Proven Best Ways to Study
The Infographics Show
https://www.youtube.com/watch?v=VJbKXmujI00

Free Resources for Students

OpenStax
https://openstax.org/

Motion Mountain
https://www.motionmountain.net/

Chris Doner IB Physics
https://www.youtube.com/user/exportationality

ilectureonline
www.ilectureonline.com

The Organic Chemistry Tutor
https://www.youtube.com/channel/UCEWpbFLzoYGPfuWUMFPSaoA

HyperPhysics
http://hyperphysics.phy-astr.gsu.edu/hbase/index.html

The Efficient Engineer
https://www.youtube.com/channel/UCXAS_Ekkq0iFJ9dSUIkcAkw

The Mechanical Universe
https://www.youtube.com/playlist?list=PL8_xPU5epJddRABXqJ5h5G0dk-XGtA5cZ

Sixty Symbols
https://www.youtube.com/user/sixtysymbols

Anton Petrov
https://www.youtube.com/c/whatdamath/featured

DrPhysicsA
https://www.youtube.com/user/DrPhysicsA

PhET Interactive Simulations
https://www.colorado.edu/csl/programs/phet-interactive-simulations

Interactive Physics Simulations
https://ophysics.com/

Fizzics Organisation
https://www.youtube.com/user/fizzicsorg

Professor Julius Sumner Miller
https://www.youtube.com/channel/UCbdjjTZBHNSgjzuJQqH5-pw

Professor Matt Anderson
https://anderson-physics.learnworlds.com/pages/home

Omni Calculator
www.omnicalculator.com

Universe & More
https://universeandmore.com/

Resources for Teachers

Five Easy Lessons: Strategies for Successful Physics Teaching
By Randall D. Knight
https://aapt.scitation.org/doi/10.1119/1.1639012
ISBN-13: 978-0805387025
ISBN-10: 0805387021

The Big Ideas in Physics and How to Teach Them
By Ben Rogers
https://the.physicsteachingpodcast.com/2018/11/29/ben-rogers-the-big-ideas-in-physics/
ISBN-13: 978-1138235069
ISBN-10: 1138235067

Teaching Introductory Physics: A Sourcebook
By Clifford E Swartz and Thomas Miner
ISBN-13: 978-1563963209

Teaching Introductory Physics
By Arnold B. Arons
ISBN-13: 978-0471137078
ISBN-10: 0471137073

Tutorials in Introductory Physics and Homework Package
By Lillian McDermott and Peter Shaffer
ISBN-13: 978-0130970695
ISBN-10: 0130970697

The Physics Classroom
https://www.physicsclassroom.com/

Name: _____

Class: _____

Due Date: _____

1.1 Measurements in Physics

Understandings

- Fundamental and derived SI units
  https://physics.nist.gov/cuu/Units/units.html
- Scientific notation and metric multipliers
  https://www.mathsisfun.com/numbers/scientific-notation.html
  https://www.chemteam.info/Metric/Metric-Prefixes.html
- Significant figures
  https://www.physics.smu.edu/cooley/phy3305/sigfigs.pdf
- Orders of magnitude
  https://openstax.org/books/college-physics/pages/1-2-physical-quantities-and-units
- Estimation
  https://physics.illinois.edu/research/estimatesresearch.pdf

Memorize these two acronyms to memorize the SI fundamental units:

My **K**nuckles **G**row **S**tronger **A**nd **K**ill **M**ore **C**reatures

=

Meters **K**ilo**G**rams **S**econds **A**mperes **K**elvin **M**oles **C**andela

If you are interested in learning more about mathematical physics then please read the books *Mathematical Methods in the Physical Sciences* by Mary L. Boas and *div grad curl and all that* by H.M. Schey.

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Define the fundamental units

https://www.nist.gov/pml/weights-and-measures/metric-si/si-units

Quantity	Unit	Definition
Length	Meters	
Mass	Kilograms	
Time	Seconds	
Current	Amperes	
Temperature	Kelvin	
Quantity	Moles	
Light intensity	Candela	

Part 2: Answer the following questions about fundamental units

https://physics.nist.gov/cuu/Units/units.html
https://www.nist.gov/pml/weights-and-measures/metric-si/si-units

1. What is the meaning and what are the fundamental units of *perimeter*?

2. What is the meaning, equation, and the fundamental units of *circumference*?

3. What is the meaning and what are the fundamental units of *area*?

4. What is the meaning and what are the fundamental units of *volume*?

5. Use the equation $\vec{v} = \frac{\Delta \vec{x}}{\Delta t}$ to solve for the fundamental units of *velocity*.

6. Use the equation $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$ to solve for the fundamental units of *acceleration*.

7. Use the equation $\vec{j} = \frac{\Delta \vec{a}}{\Delta t}$ to solve for the fundamental units of *jerk*.
https://iopscience.iop.org/article/10.1088/0143-0807/37/6/065008

8. What are the units of *force*?
http://hyperphysics.phy-astr.gsu.edu/hbase/force.html#defor

9. Use the equation $\sum \vec{F} = m\vec{a}$ to solve for the fundamental units of *force*.

10. What are the units of *energy*?
http://hyperphysics.phy-astr.gsu.edu/hbase/egex.html#eu

11. Use the equation $KE = \frac{1}{2}mv^2$ to solve for the fundamental units of *kinetic energy*.

12. Use the equation $GPE = m\vec{g}\vec{h}$ to solve for the fundamental units of the *gravitational potential energy* near the surface of a planet.

13. What are the fundamental units of *energy*?

14. What are the units of *work*?
http://hyperphysics.phy-astr.gsu.edu/hbase/work2.html#wsl

15. Use the equation $W = \vec{F}\vec{d}\cos\theta$ to solve for the fundamental units of *work W*.

16. What is the relationship between the fundamental units of *work* and *energy*?

17. What are the units of *power*?
http://hyperphysics.phy-astr.gsu.edu/hbase/pow.html#pwc

18. Use the equation $P = \frac{Energy}{time}$ to solve for the fundamental units of *power P*.

19. Use the equation $\vec{p} = m\vec{v}$ to solve for the fundamental units of *momentum* $\vec{p}$.

20. What are the units of *pressure*?
http://hyperphysics.phy-astr.gsu.edu/hbase/press.html#pre

21. Use the equation $P = F/A$ to solve for the fundamental units of *pressure P*.

22. Use the equation $PV = nRT$ to solve for the fundamental units of the *ideal gas constant R*.
http://hyperphysics.phy-astr.gsu.edu/hbase/Kinetic/idegas.html#c1

23. What is the meaning and what are the fundamental units of *period T*?
http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/sound.html#c1

24. What is the meaning and what are the fundamental units of *frequency f*?
http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/sound.html#c1

25. What is the meaning and what are the fundamental units of *wavelength λ*?
http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/sound.html#c1

26. Intensity is defined as power per unit area. What are the fundamental units of *intensity I*?

27. Use the equation $F_{electric} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$ to solve for the fundamental units of the *permittivity of free space* ε_0.

28. Use the equation $\vec{F}_E = q\vec{E}_{ext}$ to solve for the fundamental units of the *electric field E*.

29. What are the units of *current I*? Use the equation $I = \frac{\Delta q}{\Delta t}$ to solve for the fundamental units of *current I*.

30. Use the equation $I = \frac{\Delta q}{\Delta t}$ to solve for the fundamental units of *charge* q.

31. Use the equation $V = W/q$ to solve for the fundamental units of *voltage* V.

32. What are the units for the *resistance* in a resistor R?
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/resis.html#c1

33. Use the equation $V = IR$ to solve for the fundamental units of *resistance* R.

34. What are the units of *magnetic field* $\vec{B}$?
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magfie.html#c1

35. Use the equation $\vec{F}_B = q\vec{v}\vec{B}_{ext}$ to solve for the fundamental units of the *magnetic field* $\vec{B}$.

36. Use the equation $F_{gravity} = \frac{Gm_1m_2}{r^2}$ to solve for the fundamental units of the *gravitational constant* G.
http://hyperphysics.phy-astr.gsu.edu/hbase/grav.html#grav

37. Use the equation $E = hf$ to solve for the fundamental units of *Plank's constant* h.
http://hyperphysics.phy-astr.gsu.edu/hbase/mod2.html#c3

38. Use the equation $P = e\sigma AT^4$ to solve for the fundamental units of the *Stefan-Boltzmann constant* σ. The variable e is unitless.
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/stefan.html#c1

Part 3: Determine the number of significant figures

https://www.physics.smu.edu/cooley/phy3305/sigfigs.pdf
http://hyperphysics.phy-astr.gsu.edu/hbase/Mechanics/sigdig.html
http://hyperphysics.phy-astr.gsu.edu/hbase/Mechanics/sigdig.html#c1
https://openstax.org/books/university-physics-volume-1/pages/1-6-significant-figures

1. 1,000	21.0.00020	41.100.00
2. 1,000.	22.0.0205	42.300.0000
3. 1,000.00	23.0.2	43.301
4. 1,020	24.8,000	44.301.001
5. 1020.	25.8,070	45.301.0010000
6. 1,020.0	26.8.0	46.8,670
7. 1,000.001	27.8.007	47.80,600
8. 1,200	28.800,700	48.8,670.00
9. 1,200.	29.800,700.00	49.1,000,000
10.1,200.00	30.4	50.1,200,000
11.1,200.03	31.4.0	51.1,205,000
12.1,200.0300	32.4.000	52.4,000
13.100200	33.1.2	53.4,300
14.100200.	34.1.25	54.4,300.
15.100200.00	35.1.250000	55.4,030
16.4,500	36.10	56.4003
17.4,050	37.10.	57.4,003.
18.405	38.100	
19.0.0000405	39.101	
20.0.0002	40.100.	

Part 4: Watch the video *Scale of the Universe* in the link below and browse online to answer the following questions

http://www.htwins.net/scale2/

Object	What is it? Describe it	Length (m) and mass (kg)
Quantum foam		9.3×10^{-36}
		No mass
String		
		No mass
Planck length		
		No mass
Neutrino		

Smallest quark		
Range of the weak force		No mass
Proton		
Neutron		
Helium nucleus		
Electron		

Uranium nucleus		
Gamma ray wavelength		
		No mass
Hydrogen atom		
Smallest thing visible to an electron microscope		
		No mass
X-ray wavelength		
		No mass
Transistor gate		

Ultraviolet wavelength		
		No mass
Smallest object visible to the naked eye		
		No mass
Microwave wavelength		
		No mass
Burj Khalifa		
Mount Everest		
Earth		

Distance from Earth to Moon		
		No mass
The Sun		
Distance from Earth to Sun		
		No mass
Light-year		
		No mass
Observable Universe		
Universe		

Part 5: Unit conversions

1. A man has a mass of 80 kg. What is the mass of the man in pounds? Show all your work and place a box around your answer.

2. How many seconds are in 80 years? Show all your work and place a box around your answer.

3. In 2009 Usain Bolt ran 100 m in a record time of 9.58 s. If he continues to run at this constant rate then how many meters will he run in one day? Show all your work and place a box around your answer.

4. In 2018 Eliud Kipchoge ran a marathon (42.195 km) in a record time of 2:01:39. If he continues to run at this constant rate then how many meters will he run in one day? Show all your work and place a box around your answer.

5. The circumference of the Earth is about 40,075.017 km from the Equator. What is the circumference of the Earth in inches? Show all your work and place a box around your answer.

6. The surface area of Earth is about 510,064,472 square kilometers. What is the surface area of the Earth in square inches? Show all your work and place a box around your answer.

7. The volume of Earth is about 1,083,206,916,846 cubic kilometers. What is the volume of Earth in cubic inches? Show all your work and place a box around your answer.

8. The speed of light is 299,792,458 m/s. What is the distance, in kilometers, light travels in one year? Show all your work and place a box around your answer.

9. The density of gold is 19.32 grams per cubic centimeters. What is the density of gold in kilograms per cubic meters? Show all your work and place a box around your answer.

10. The density of gold is 19.32 grams per cubic centimeters. What is the density of gold in pounds per cubic feet? Show all your work and place a box around your answer.

11. A man drinks 60 liters of water in a 30 day month. On average how many cubic meters of water does he drink per hour? Show all your work and place a box around your answer.

Name: _____

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1.2 Uncertainties and Errors

Understandings

- Random and systematic errors
  https://www.physics.umd.edu/courses/Phys276/Hill/Information/Notes/ErrorAnalysis.html
- Absolute, fractional, and percentage uncertainties
- Error bars
  http://www.schoolphysics.co.uk/age16-19/General/text/Uncertainties_in_graphs/index.html
  http://skipper.physics.sunysb.edu/~physlab/doku.php?id=phy133:error_and_uncertainty
  https://labwrite.ncsu.edu/res/gt/gt-stat-home.html
- Uncertainty of gradient and intercepts
  http://www.mrphysicsportal.net/physicshl/experiments/loggerpro.uncertaintycalculations.pdf

Equations

If $y = a \pm b$ then $\Delta y = \Delta a + \Delta b$

If $y = \frac{ab}{c}$ then $\frac{\Delta y}{y} = \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta c}{c}$

If $y = a^n$ then $\frac{\Delta y}{y} = \left| n \frac{\Delta a}{a} \right|$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions.

1. Define *random error*. Give two examples of *random error*.
   https://www.physics.umd.edu/courses/Phys276/Hill/Information/Notes/ErrorAnalysis.html

2. Define *systematic error*. Give two examples of *systematic error*.
   https://www.physics.umd.edu/courses/Phys276/Hill/Information/Notes/ErrorAnalysis.html

3. Define *accuracy*. Give an example of *high accuracy* and *low accuracy*.
   https://physicsabout.com/accuracy-and-precision/

4. Define *precision*. Give an example of *high precision* and *low precision*.
   https://physicsabout.com/accuracy-and-precision/

5. List some rules with regards to *uncertainties in measurements*.
   https://www.deanza.edu/faculty/lunaeduardo/documents/MeasurementsUncertainties2A.pdf
   https://www.physics.upenn.edu/sites/default/files/Managing%20Errors%20and%20Uncertainty.pdf

6. State the equation and give the meaning of *standard deviation.*
   https://www.mathsisfun.com/data/standard-deviation.html

7. Calculate the *absolute uncertainty*, *fractional uncertainty*, and *percent uncertainty* for a measured length $(87.65 \pm 0.43)\ m$.
   https://studynova.com/lecture/physics/measurement-and-uncertainty/absolute-fractional-percentage-uncertainty/

8. **Use a pencil and ruler!** Draw a simple but neat graph of a *displacement vs. time* graph with measurement points and a best-fit line. https://www.varsitytutors.com/hotmath/hotmath_help/topics/line-of-best-fit

Part 2: Learn how to add, subtract, multiply, and divide uncertainties
http://hyperphysics.phy-astr.gsu.edu/hbase/Mechanics/sigdig.html#c1

If $y = a \pm b$ then $\Delta y = \Delta a + \Delta b$

1. 3.14 ± 0.15
$+ \quad 9.26 \pm 0.53$

2. 6.26 ± 0.43
$+ \quad 3.8 \ \pm 0.27$

3. 1.69 ± 0.39
$+ \quad 9.37 \pm 0.51$

4. $\begin{array}{rl} & 5.89 \pm 0.79 \\ - & 3.23 \pm 0.84 \end{array}$

5. $\begin{array}{rl} & 9.50 \pm 0.28 \\ - & 8.4 \ \pm 0.97 \end{array}$

6. $\begin{array}{rl} & 5.82 \pm 0.09 \\ - & 4.94 \pm 0.45 \end{array}$

If $y = \frac{ab}{c}$ then $\frac{\Delta y}{y} = \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta c}{c}$

7. 3.14 ± 0.15
$\times \quad 9.26 \pm 0.53$

8. 6.26 ± 0.43
$\times \quad 3.8 \ \pm 0.27$

9. 1.69 ± 0.39
$\times \quad 9.37 \pm 0.51$

10. 5.89 ± 0.79
$\div \quad 3.23 \pm 0.84$

11. 9.50 ± 0.28
$\div \quad 8.4 \pm 0.97$

12. 5.82 ± 0.09
$\div \quad 4.94 \pm 0.45$

If $y = a^n$ then $\frac{\Delta y}{y} = \left| n \frac{\Delta a}{a} \right|$

13. $(3.14 \pm 0.15)^2$

14. $(9.26 \pm 0.53)^3$

15. $(6.26 \pm 0.43)^4$

16. $\sqrt{(3.14 \pm 0.15)}$

17. $\sqrt[3]{(9.26 \pm 0.53)}$

18. $\sqrt[4]{(6.26 \pm 0.43)}$

19. What is the percent uncertainty of the perimeter of a rectangle if has a length of $2.45 \pm 0.3\ m$ and a width of $3.56 \pm 0.4\ m$?

20. What is the percent uncertainty of the area of a rectangle if its length is uncertain by 3% and its height is uncertain by 4%?

21. What is the percent uncertainty of the volume of a box if its length is uncertain by 3%, its width is uncertain by 4%, and its height is uncertain by 5%?

22. What is the percent uncertainty of the perimeter of a circle if its radius is uncertain by 7%?

23. What is the percent uncertainty of the area of a circle if its radius is uncertain by 7%?

24. What is the percent uncertainty of the volume of a sphere if its radius is uncertain by 7%?

25. Mustafa has a height of $172 \pm 0.2\ cm$. Nour has a height of $167 \pm 0.35\ cm$. How much taller, including uncertainty, is Mustafa taller than Nour?

26. Twelve identical square tiles each have a length of $45.62\ cm$ with an uncertainty of $0.2\ cm$. What is the total length, including uncertainty, of the 12 tiles if they are each placed side-by-side?

27. What is the perimeter, including uncertainty, of a rectangle with a length of $3.14 \pm 0.15\ cm$ and a height of $9.26 \pm 0.53\ cm$?

28. What is the area, including uncertainty, of a rectangle with a length of $3.14 \pm 0.15\ cm$ and a height of $9.26 \pm 0.53\ cm$?

29. What is the volume, including uncertainty, of a box with a length of $3.14 \pm 0.15\ cm$, a base of $9.26 \pm 0.53\ cm$, and a height of $6.26 \pm 0.43\ cm$?

30. What is the perimeter, including uncertainty, of a circle with radius of $3.83 \pm 0.27\ cm$?

31. What is the area, including uncertainty, of a circle with radius of $3.83 \pm 0.27\ cm$?

32. What is the volume, including uncertainty, of a sphere with radius of $3.83 \pm 0.27\ cm$?

33. What is the speed, including uncertainty, of a boat which travels $31.41 \pm 0.59\ m$ in $2.65 \pm 0.35\ s$?

Name: _____

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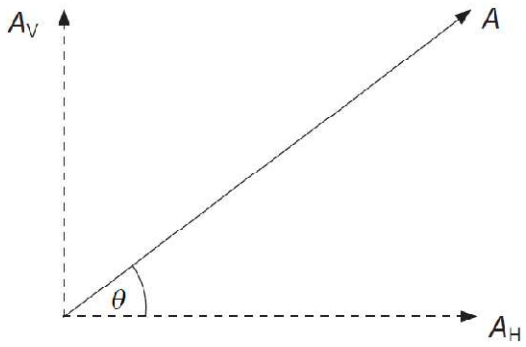
1.3 Vectors and Scalars

Understandings

- Vector and scalar quantities
  https://openstax.org/books/university-physics-volume-1/pages/2-1-scalars-and-vectors
- Combination and resolution of vectors
  https://openstax.org/books/university-physics-volume-1/pages/2-3-algebra-of-vectors

Equations



$A_H = A\cos\theta$

$A_V = A\sin\theta$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Define the following terms

1. magnitude
   www.dictionary.com

2. scalar
   https://openstax.org/books/college-physics/pages/2-2-vectors-scalars-and-coordinate-systems

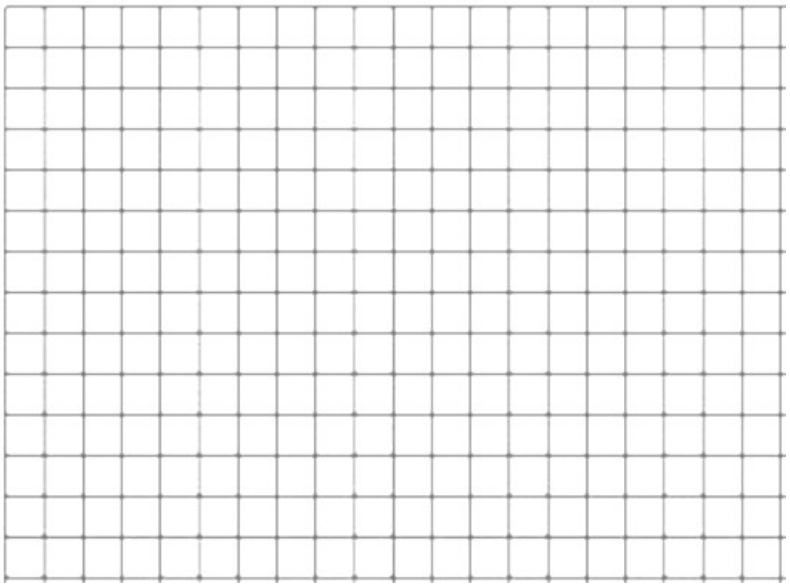
3. vector (What is the symbol for a vector?)
   https://openstax.org/books/college-physics/pages/2-2-vectors-scalars-and-coordinate-systems

Part 2: Determine if the following quantities are *scalars* or *vectors*.

1. Money	23. Impulse
2. Perimeter	24. Pressure
3. Circumference	25. Moles
4. Area	26. Temperature
5. Volume	27. Wavelength
6. Angle	28. Period
7. Time	29. Frequency
8. Length	30. Charge
9. Distance	31. Current
10. Displacement	32. Voltage
11. Speed	33. Gravitational field strength
12. Velocity	34. Energy density
13. Acceleration	35. Specific energy
14. Jerk (derivative of acceleration)	36. Angular speed
15. Force	37. Angular acceleration
16. Work	38. Electric Potential
17. Calories	39. Electric field
18. Energy	40. Magnetic field
19. Kinetic energy	41. Electromotive force
20. Potential energy	42. Moment of inertia
21. Power	43. Entropy
22. Momentum	44. Reynold's number

Part 3: Drawing vectors. Use a pencil and ruler!

1. Let the vectors $\vec{A} = (x_1, y_1) = (3, -2)$ and $\vec{B} = (x_2, y_2) = (-1,4)$
   a. Draw a horizontal and vertical axis on the graph below. Label the horizontal axis *x* and the vertical axis *y*.
   b. Draw $\vec{A}$ on the graph below.
   c. What is the magnitude of the horizontal component of $\vec{A}$?
   d. What is the magnitude of the vertical component of $\vec{A}$?
   e. What is the magnitude of $\vec{A}$?
   f. Draw $\vec{B}$ on the graph below.
   g. What is $\vec{A} + \vec{B}$? Draw it on the graph below.
   h. What is the magnitude of the horizontal component of $\vec{A} + \vec{B}$?
   i. What is the magnitude of the vertical component of $\vec{A} + \vec{B}$?
   j. What is the magnitude of $\vec{A} + \vec{B}$?
   k. What is $\vec{B} + \vec{A}$? Draw it on the graph below.
   l. What is $\vec{A} - \vec{B}$? Draw it on the graph below.
   m. What is $\vec{B} - \vec{A}$? Draw it on the graph below.
   n. What is $-\vec{A} - \vec{B}$? Draw it on the graph below.
   o. What is $-\vec{B} - \vec{A}$? Draw it on the graph below.



Part 4: The classic "boat crossing a river" problem

1. Adam is on a boat. It is moving from south to north on a river at a speed of 9 m/s. The water in the river is moving from east to west with a speed of 4 m/s. The river is 81 m wide.
   a. Draw a figure.
   b. How long will it take for the boat to reach the other side?
   c. How many meters will the boat have traveled westward?
   d. What will be the total displacement of the boat?

http://hyperphysics.phy-astr.gsu.edu/hbase/boatc.html#c1

Boat Crossing River
Matt Anderson
https://www.youtube.com/watch?v=bUfXCh0xBzg

Name: _____

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2.1 - Motion

Understandings

- Distance and displacement
  http://hyperphysics.phy-astr.gsu.edu/hbase/posit.html#c2
  https://openstax.org/books/university-physics-volume-1/pages/3-1-position-displacement-and-average-velocity
- Speed and velocity
  http://hyperphysics.phy-astr.gsu.edu/hbase/vel2.html#c1
  https://openstax.org/books/university-physics-volume-1/pages/3-2-instantaneous-velocity-and-speed
- Acceleration
  http://hyperphysics.phy-astr.gsu.edu/hbase/acca.html#c1
  https://openstax.org/books/university-physics-volume-1/pages/3-3-average-and-instantaneous-acceleration
- Graphs describing motion
  http://hyperphysics.phy-astr.gsu.edu/hbase/Mechanics/motgraph.html
  https://openstax.org/books/university-physics-volume-1/pages/3-6-finding-velocity-and-displacement-from-acceleration
  https://universeandmore.com/
- Equations of motion for uniform acceleration
  http://hyperphysics.phy-astr.gsu.edu/hbase/mot.html#mot1
  https://openstax.org/books/university-physics-volume-1/pages/3-4-motion-with-constant-acceleration
- Projectile motion
  http://hyperphysics.phy-astr.gsu.edu/hbase/traj.html#tracon
- Fluid resistance and terminal speed
  http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
  http://hyperphysics.phy-astr.gsu.edu/hbase/airfri.html#c4

Equations

$v_f = at + v_i$

$x_f = \frac{1}{2}at^2 + v_i t + x_i$

$v_f{}^2 - v_i{}^2 = 2a(x_f - x_i)$

$x = \frac{(v_i + v_f)t}{2}$

$\bar{\vec{v}} = \frac{\vec{v}_i + \vec{v}_f}{2}$

Interesting facts

- The record for the tallest person in the world is Robert Wadlow who measured 272 cm. He died at the age of 22.
- The record for the tallest building in the world is the Burj Khalifa in the United Arab Emirates which is almost 830 m tall.
- The record for the tallest mountain above sea level is Mount Everest which is located between China and Nepal. It is measured to be about 8,848 m above sea level.
- The record for the lowest depth below sea level is the Mariana Trench which is about 10,984 m below sea level. Surprisingly both life and pollution is found near the bottom of the Marina Trench.
- The fastest baseball pitch ever recorded is from Aroldis Chapman at which was about 169.1 km/h or 46.97 m/s.

Super Ultimate Graphing Challenge
http://theuniverseandmore.com/

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions.

1. What is the meaning of zero dimensions? One dimension? Two dimensions? Three dimensions? Four dimensions? If possible draw a figure for each.

2. Define *position.*
   www.dictionary.com

3. Define *distance.* Is it a scalar or vector? Units? Example? Can *distance* be negative?
   https://www.dictionary.com/browse/distance?s=t

4. Define *displacement.* Is it a scalar or vector? Units? Example? Can *displacement* be negative?
   http://hyperphysics.phy-astr.gsu.edu/hbase/posit.html#c1

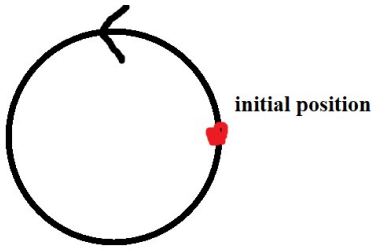
5. Define *speed*. Is it a scalar or vector? Equation? Units? Example? Can *speed* be negative?
   http://hyperphysics.phy-astr.gsu.edu/hbase/vel2.html#c1

6. Define *velocity*. Is it a scalar or vector? Equation? Units? Example? Can *velocity* be negative?
   http://hyperphysics.phy-astr.gsu.edu/hbase/vel2.html#c1

7. Define *average speed*. Is it a scalar or vector? Equation? Units?
   http://hyperphysics.phy-astr.gsu.edu/hbase/vel2.html#c1

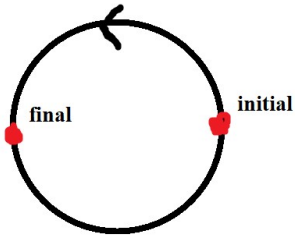
8. Define *average velocity*. Is it a scalar or vector? Equation? Units?
   http://hyperphysics.phy-astr.gsu.edu/hbase/vel2.html#c1

9. An object moves in a circle with a radius of 3 m. It completes one revolution in a time of 4 seconds.

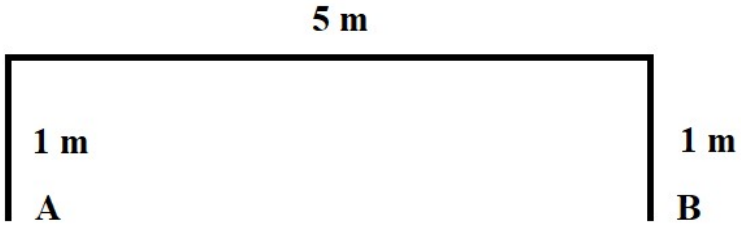


a. What is the *average speed* and the *average velocity* of the object after it completes **<u>one</u>** cycle/revolution?

b. What is the *average speed* and the *average velocity* of the object after it completes **<u>one-half</u>** cycle/revolution?



10. An object starts from rest at point A and then travels to point B by moving north 1 m, then east 5 m, and finally south 1 m in a total time of 14 seconds. What is the *average speed* and the *average velocity* of the object when it moves from point A to point B?



11. Define *instantaneous speed*. Is it a scalar or vector? Example?
http://hyperphysics.phy-astr.gsu.edu/hbase/vel2.html#c1

12. Define *instantaneous velocity*. Is it a scalar or vector? Example?
http://hyperphysics.phy-astr.gsu.edu/hbase/vel2.html#c1

13. Define *acceleration*. Is it a scalar or vector? Equation? Units? Example? Can *acceleration* be negative?
http://hyperphysics.phy-astr.gsu.edu/hbase/acca.html#c1

14. What is the magnitude of the acceleration of free fall $\vec{g}$ near the surface of the Earth? Which direction/way does it point? Is it positive or negative?
http://hyperphysics.phy-astr.gsu.edu/hbase/traj.html
http://hyperphysics.phy-astr.gsu.edu/hbase/Class/PhSciLab/freefall.html

15. Define *projectile motion.*

16. What does the slope of a *displacement vs. time* graph tell us? Equation? Units? http://hyperphysics.phy-astr.gsu.edu/hbase/Mechanics/motgraph.html#c1

17. What does the slope of a *velocity vs. time* graph tell us? Equation? Units?

18. What does the slope of an *acceleration vs. time* graph tell us? Equation? Units?

19. What does the area under a *displacement vs. time* graph tell us? Units?

20. What does the area under a *velocity vs. time* graph tell us? Units?

21. What does the area under an *acceleration vs. time* graph tell us? Units?

22. How would you go about determining the acceleration due to gravity near the surface of the Earth? Which equation will you use? Which instruments do you need? What will you do?

23. **Use a pencil and ruler!** Define *terminal velocity*. What is the relationship between speed and the force of friction? Draw a *distance vs. time* graph, a *speed vs. time* graph, and an *acceleration vs. time* graph of an object being dropped from rest from a very high height above the surface of the Earth with both the force of friction and the force of gravity acting on it.
https://openstax.org/books/university-physics-volume-1/pages/6-4-drag-force-and-terminal-speed
http://hyperphysics.phy-astr.gsu.edu/hbase/lindrg.html
http://hyperphysics.phy-astr.gsu.edu/hbase/airfri2.html#c1

24. **Use a pencil and ruler!** Draw a *speed vs. time* graph of a skydiver first jumping out of an airplane, then reaching terminal velocity, then opening his parachute, then reaching a second terminal velocity, and finally hitting the ground.

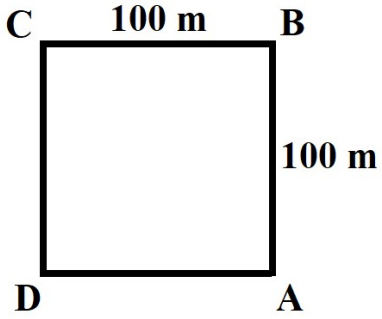
25. A ball is thrown vertically upwards with an initial velocity of 40 m/s in the absence of air friction. For this problem let the acceleration due to gravity be 10 m/s^2 down. Fill out the table below:

Time (s)	Acceleration (m/s^2)	Velocity (m/s) $v_f = at + v_i$	Displacement (m) $y_f = \frac{1}{2}at^2 + v_i t + y_i$	Total distance traveled (m)
0				
1				
2				
3				
4				
5				
6				
7				
8				

Use a pencil and ruler! Draw an *acceleration vs. time* graph, a *velocity vs. time* graph, a *speed vs. time* graph, a *displacement vs. time* graph, and a *distance vs. time* graph for the ball.

Part 2: Distance Displacement Speed Velocity

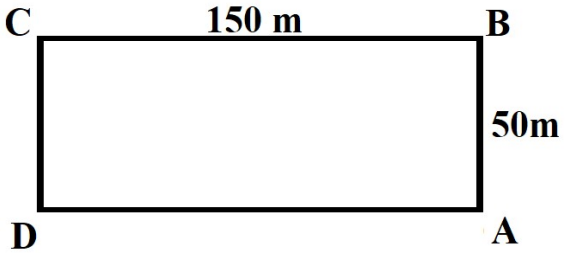
1. Wayde Van Niekerk from Russia runs 400 meters at a constant speed around a square track in a time of 43.03 seconds beginning at point A in a counterclockwise direction as shown below.



Complete the following table by determining the distance, displacement, speed, and velocity of Wayde Van Kiekerk at the following points. State both the magnitude and direction for the displacement and velocity of Wayde Van Kiekerk.

	Point B	Point C	Point D	Point A
Total Distance				
Total Displacement				
Average Speed				
Average Velocity				

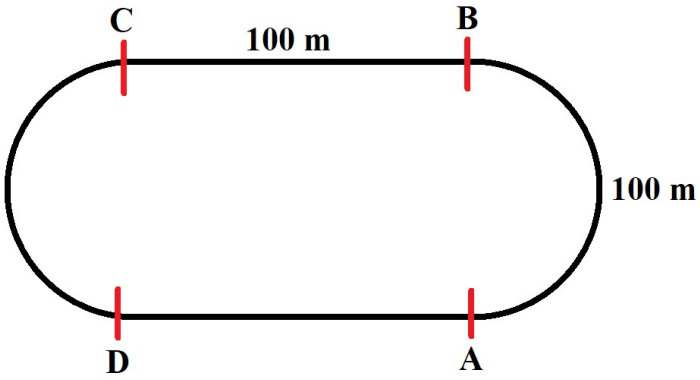
2. Wayde Van Niekerk from Russia runs 400 meters at a constant speed around a rectangular track in a time of 43.03 seconds beginning at point A in a counterclockwise direction as shown below.



Complete the following table by determining the distance, displacement, speed, and velocity of Wayde Van Kiekerk at the following points. State both the magnitude and direction for the displacement and velocity of Wayde Van Kiekerk.

	Point B	Point C	Point D	Point A
Total Distance				
Total Displacement				
Average Speed				
Average Velocity				

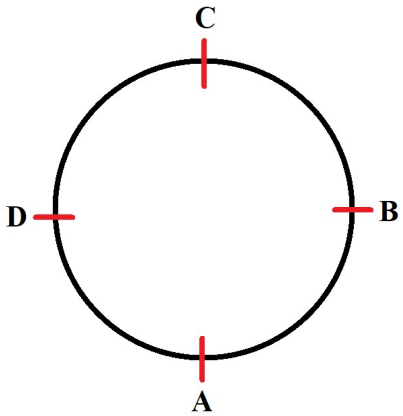
3. Wayde Van Niekerk from Russia runs 400 meters at a constant speed around an Olympic track in a time of 43.03 seconds beginning at point A in a counterclockwise direction as shown below. Each semicircle has a length of 100 meters.



Complete the following table by determining the distance, displacement, speed, and velocity of Wayde Van Kiekerk at the following points. State both the magnitude and direction for the displacement and velocity of Wayde Van Kiekerk.

	Point B	Point C	Point D	Point A
Total Distance				
Total Displacement				
Average Speed				
Average Velocity				

4. Wayde Van Niekerk from Russia runs 400 meters at a constant speed around a circular track in a time of 43.03 seconds beginning at point A in a counterclockwise direction as shown below.

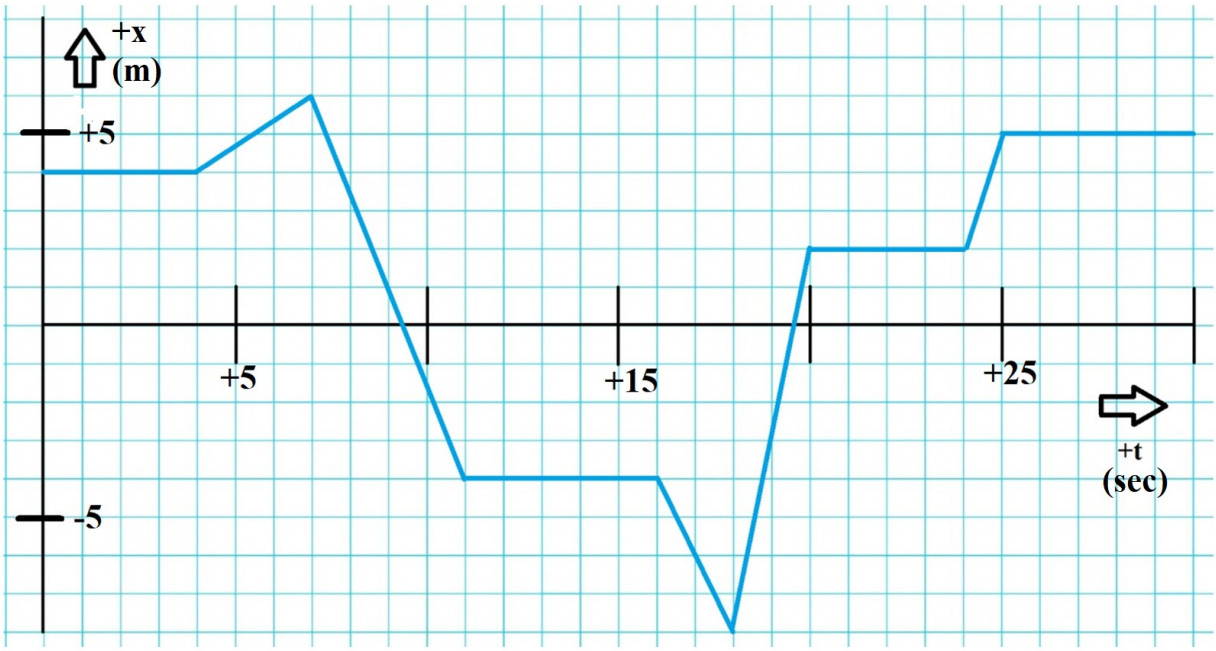


Complete the following table by determining the distance, displacement, speed, and velocity of Wayde Van Kiekerk at the following points. State both the magnitude and direction for the displacement and velocity of Wayde Van Kiekerk.

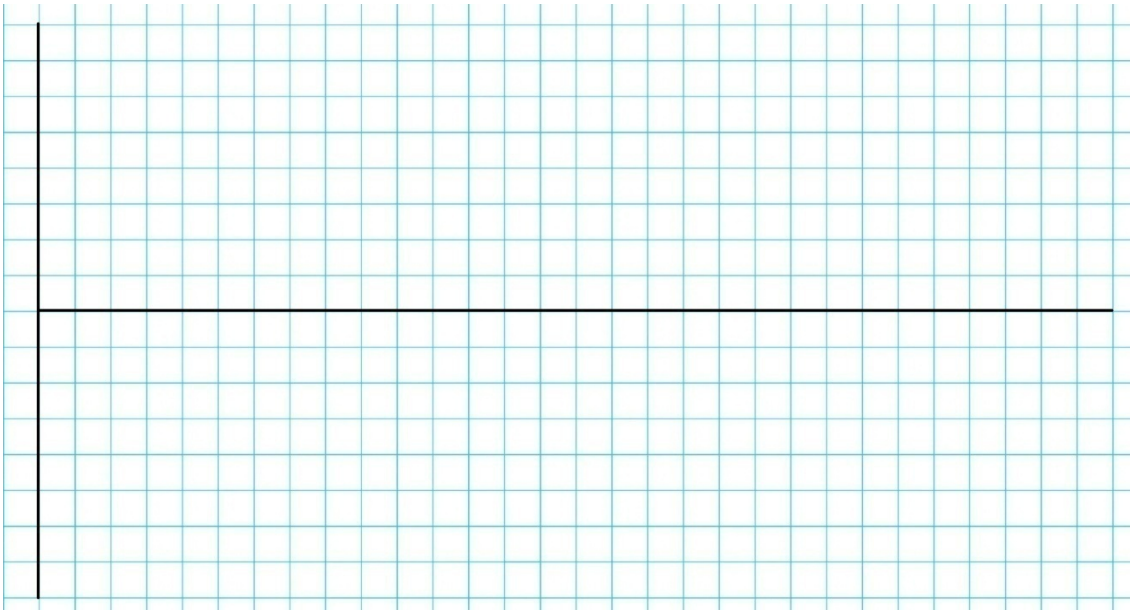
	Point B	Point C	Point D	Point A
Total Distance				
Total Displacement				
Average Speed				
Average Velocity				

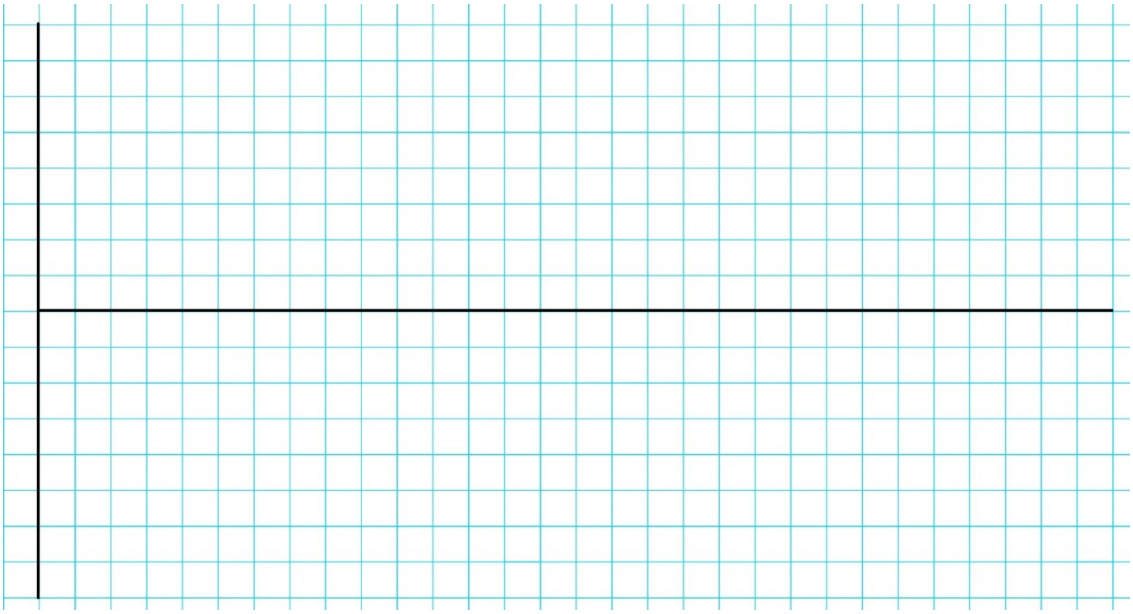
Part 3: Motion graphs

1. An object can move to the left or right in one dimension. Positive displacement is towards the right and negative displacement is towards the left. Its *displacement vs. time* graph is shown below.

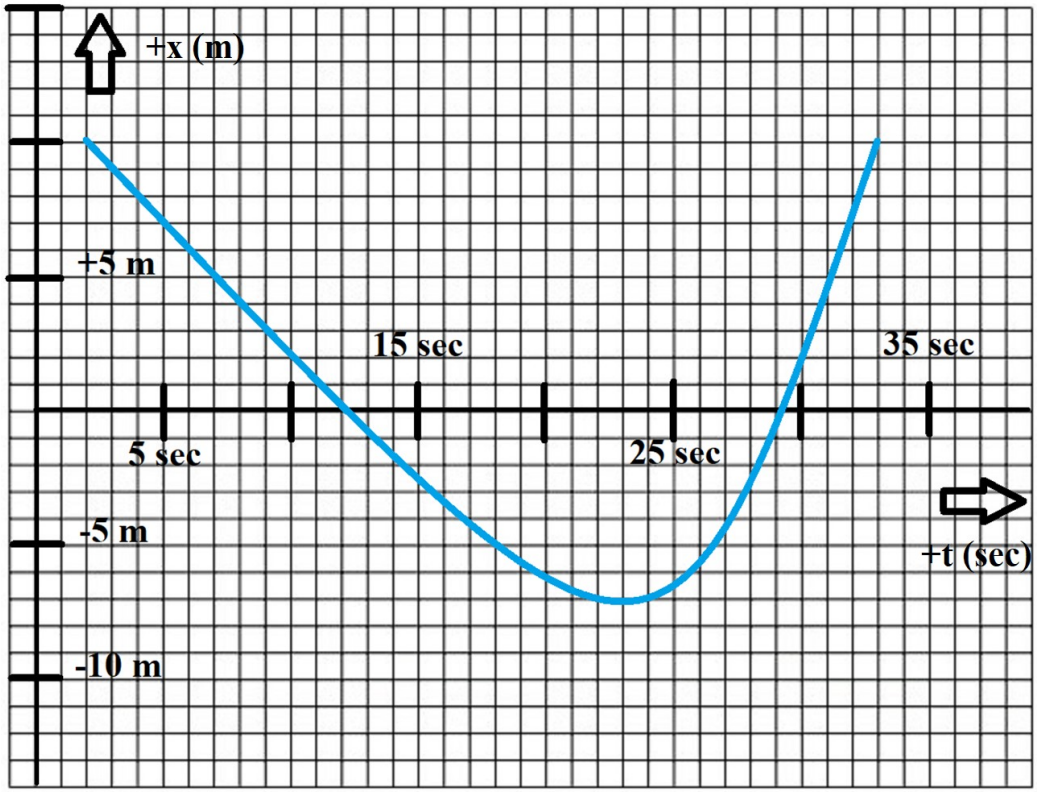


a. What does the slope of a *displacement vs. time* graph tell us?
b. Determine the *displacement* and *velocity* of the object at
   i. $t = 3\ s$
   ii. $t = 5\ s$
   iii. $t = 9\ s$
   iv. $t = 13\ s$
   v. $t = 17\ s$
   vi. $t = 19\ s$
   vii. $t = 23\ s$
   viii. $t = 24.5\ s$
   ix. $t = 28\ s$
c. What is the *total distance* the object travels from $t = 0\ s$ to $t = 30\ s$?
d. What is the *displacement* of the object from $t = 0\ s$ to $t = 30\ s$?
e. What does the slope of a *velocity vs. time* graph tell us?
f. **Use a pencil and ruler!** On the next page draw a *velocity vs. time* graph and an *acceleration vs. time* graph. Label your axes!





2. An object can move to the left or right in one dimension. Positive displacement is towards the right and negative displacement is towards the left. Its *displacement vs. time* graph is shown below.



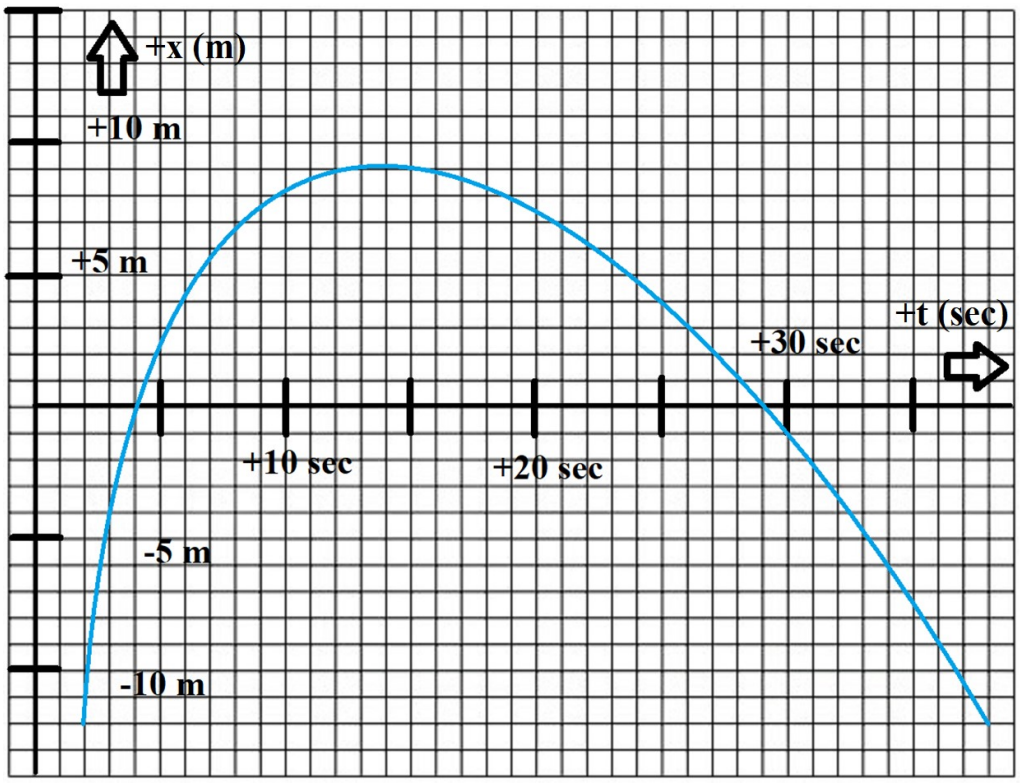
a. Is the object moving to the left or the right? Is it speeding up or slowing down?
   i. From $t = 2\ s$ to $t = 12\ s$
   ii. From $t = 12\ s$ to $t = 23\ s$
   iii. From $t = 23\ s$ to $t = 29\ s$
   iv. From $t = 29\ s$ to $t = 33\ s$

b. Determine the *displacement* and *velocity* of the object at
   i. $t = 12\ s$
   ii. $t = 23\ s$
   iii. $t = 29\ s$

c. What is the *total distance* the object travels from $t = 2\ s$ to $t = 33\ s$?

d. What is the *displacement* of the object from $t = 2\ s$ to $t = 33\ s$?

3. An object can move to the left or right in one dimension. Positive displacement is towards the right and negative displacement is towards the left. Its *displacement vs. time* graph is shown below.



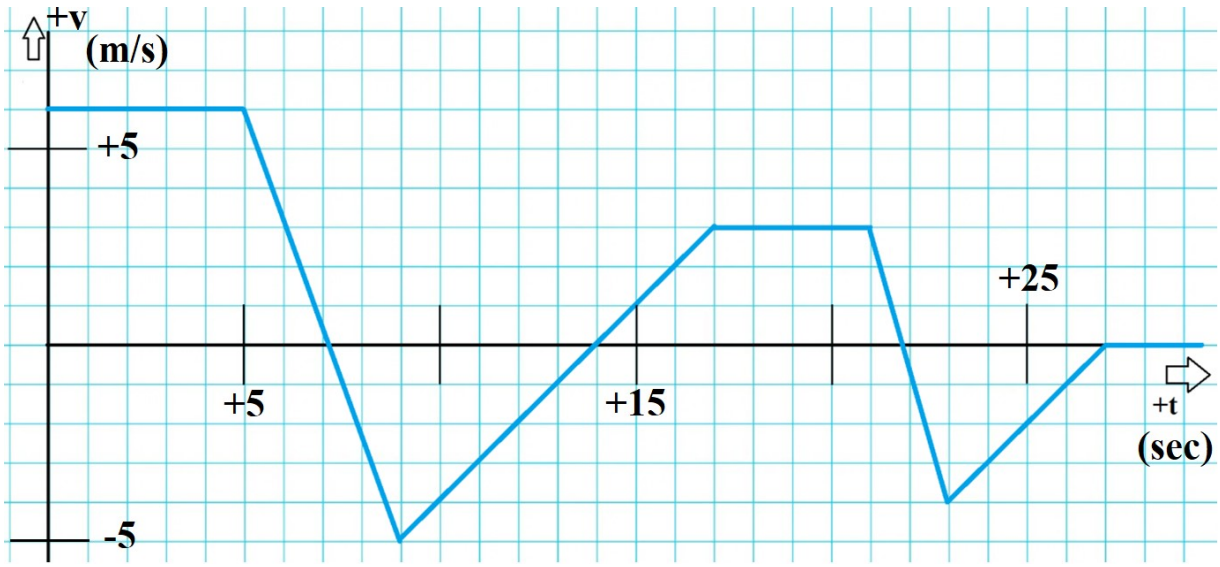
a. Is the object moving to the left or the right? Is it speeding up or slowing down?
   i. From $t = 2\ s$ to $t = 4\ s$
   ii. From $t = 4\ s$ to $t = 14\ s$
   iii. From $t = 14\ s$ to $t = 29\ s$
   iv. From $t = 29\ s$ to $t = 38\ s$

b. Determine the *displacement* and *velocity* of the object at
   i. $t = 4\ s$
   ii. $t = 14\ s$
   iii. $t = 29\ s$

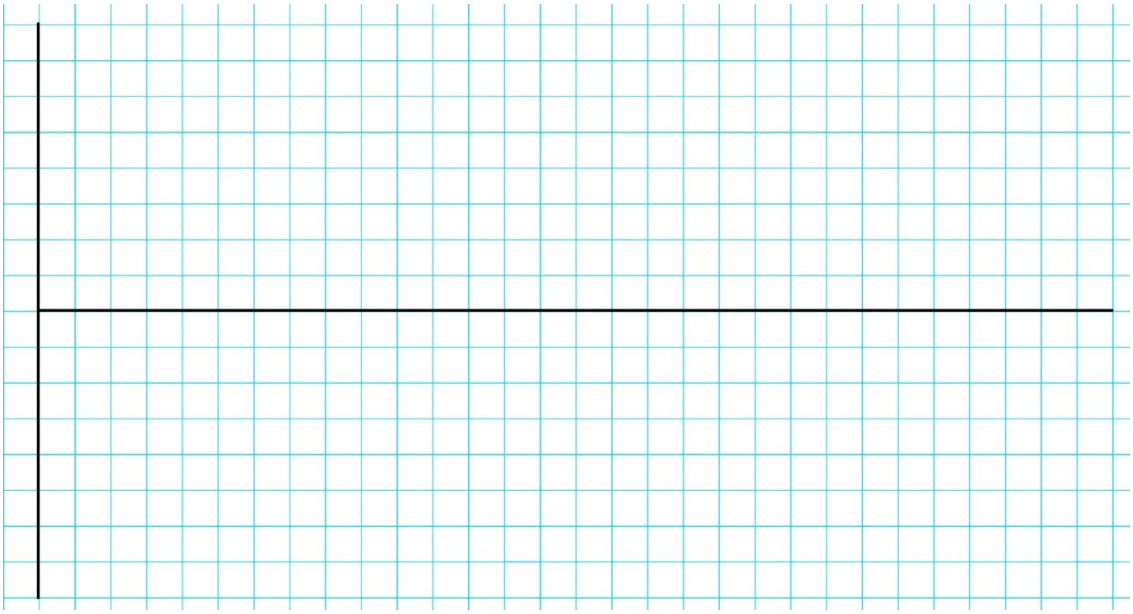
c. What is the *total distance* the object travels from $t = 2\ s$ to $t = 38\ s$?

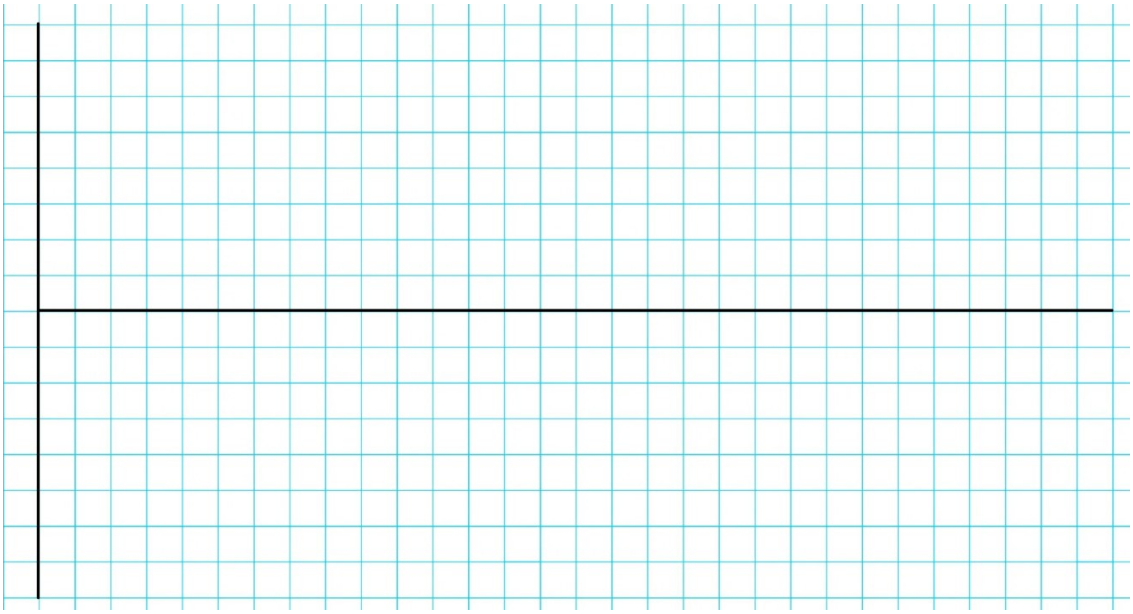
d. What is the *displacement* of the object from $t = 2\ s$ to $t = 38\ s$?

4. An object can move to the left or right in one dimension. Positive displacement is towards the right and negative displacement is towards the left. Its *velocity vs. time* graph is shown below.

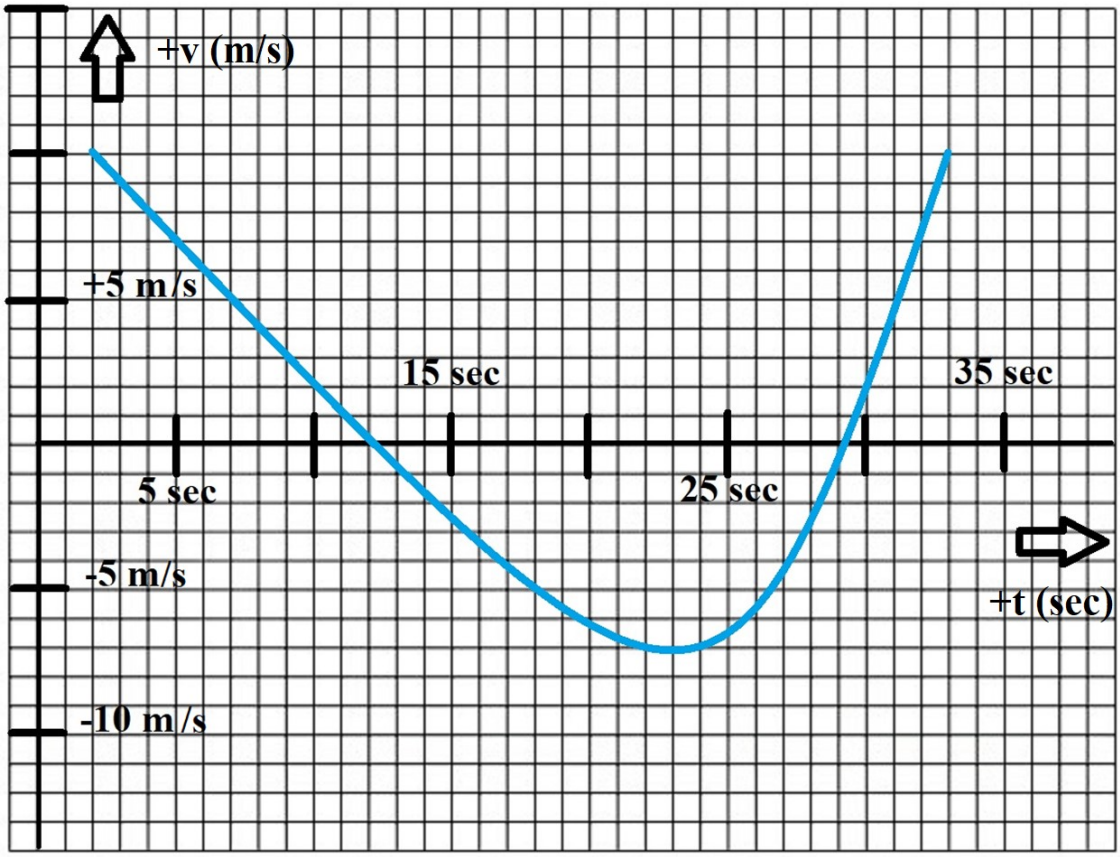


a. What does the slope of a *velocity vs. time* graph tell us?
b. Find the *velocity* and the *acceleration* of the object at
   i. $t = 3\ s$
   ii. $t = 7\ s$
   iii. $t = 8\ s$
   iv. $t = 10\ s$
   v. $t = 14\ s$
   vi. $t = 18\ s$
   vii. $t = 22\ s$
   viii. $t = 29\ s$
c. What does the area under a *velocity vs. time* graph tell us?
d. Find the *displacement* of the object from
   i. $t = 0\ s$ to $t = 5\ s$
   ii. $t = 5\ s$ to $t = 9\ s$
   iii. $t = 9\ s$ to $t = 17\ s$
   iv. $t = 17\ s$ to $t = 27\ s$
e. Determine the *total distance* the object travels from $t = 0\ s$ to $t = 29\ s$.
f. Determine the *displacement* of the object from $t = 0\ s$ to $t = 29\ s$.
g. **Use a pencil and ruler!** On the next page draw an *acceleration vs. time* graph and a *displacement vs. time* graph. Label your axes!





5. An object can move to the left or right in one dimension. Positive displacement is towards the right and negative displacement is towards the left. Its *velocity vs. time* graph is shown below.



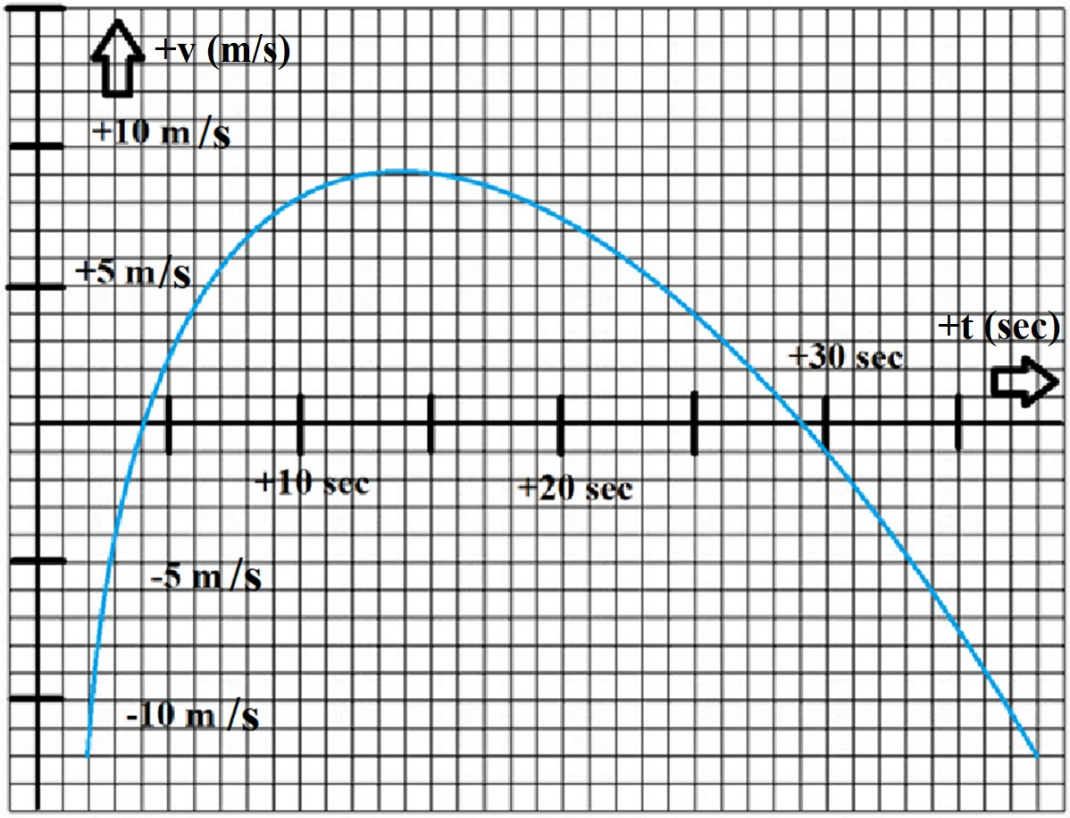
a. Is the object moving to the left or the right? Is its acceleration increasing, decreasing, or constant?
   i. From $t = 2\ s$ to $t = 12\ s$
   ii. From $t = 12\ s$ to $t = 23\ s$
   iii. From $t = 23\ s$ to $t = 29\ s$
   iv. From $t = 29\ s$ to $t = 33\ s$

b. Determine the *velocity* and *acceleration* of the object at
   i. $t = 12\ s$
   ii. $t = 23\ s$
   iii. $t = 29\ s$

c. Determine the *total distance* the object travels from $t = 2\ s$ to $t = 33\ s$.

d. Determine the *displacement* of the object from $t = 2\ s$ to $t = 33\ s$.

6. An object can move to the left or right in one dimension. Positive displacement is towards the right and negative displacement is towards the left. Its *velocity vs. time* graph is shown below.



a. Is the object moving to the left or the right? Is its acceleration increasing, decreasing, or constant?
   i. From $t = 2\ s$ to $t = 4\ s$
   ii. From $t = 4\ s$ to $t = 14\ s$
   iii. From $t = 14\ s$ to $t = 29\ s$
   iv. From $t = 29\ s$ to $t = 38\ s$

b. Determine the *velocity* and *acceleration* of the object at
   i. $t = 4\ s$
   ii. $t = 14\ s$
   iii. $t = 29\ s$

c. Determine the *total distance* the object travels from $t = 2\ s$ to $t = 38\ s$.

d. Determine the *displacement* of the object from $t = 2\ s$ to $t = 38\ s$.

Part 4: Motion equations

There is no air friction for all the problems. The magnitude of the acceleration from gravity is 9.81 m/s^2. Round your answers to two decimal points.

http://hyperphysics.phy-astr.gsu.edu/hbase/mot.html#mot1

http://hyperphysics.phy-astr.gsu.edu/hbase/traj.html#tracon

1. A car starts from rest and speeds up to 35 m/s in 12 seconds.
    a. What is the average acceleration of the car during these 12 seconds?
    b. What is the total distance traveled by the car during these 12 seconds?

   The car then travels at a constant speed of 35 m/s for 900 meters.
    c. How long was the car travelling at this constant speed?

   The car finally slows down from 35 m/s to 15 m/s in four seconds.
    d. What is the average acceleration (or deceleration) of the car during these four seconds?
    e. What is the total distance the car travels during these four seconds?
    f. What is the total distance the car travels since it started from rest?
    g. What is the total time taken for the car to travel since it started from rest until it reaches a speed of 15 m/s?
    h. Draw a displacement vs. time graph, a velocity vs. time graph, and an acceleration vs. time graph for the car.

2. A car starts from rest and accelerates at a constant rate of 4 m/s^2 for 8 seconds.
    a. What is the speed of the car after 8 seconds?
    b. How much distance did the car travel during these 8 seconds?

   The car then moves at a constant speed for 12 seconds.
    c. How much distance did the car travel during these 12 seconds?

   The car then slows to a stop at a rate of 3 m/s^2.
    d. How much time did it take for the car to decelerate and stop?
    e. How much distance did the car travel when it decelerates?
    f. What is the total time taken for the car to travel?
    g. What is the total distance taken for the car to travel?
    h. Draw a displacement vs. time graph, a velocity vs. time graph, and an acceleration vs. time graph for the car.

3. Enoch throws a ball vertically upwards with an initial speed of 47 m/s at an elevation of 8,848 m above the surface of the Earth.
   a. What will be the acceleration of the ball (number and direction) at the moment after it is thrown upwards?
   b. What will be the acceleration of the ball (number and direction) when it reaches its maximum height?
   c. What will be the velocity of the ball when it reaches its maximum height?
   d. How long will it take for the ball to reach its maximum height?
   e. How many meters above the surface of the Earth will the ball be when it reaches its maximum height?
   f. What will be the acceleration of the ball (number and direction) just before it strikes the surface of the Earth?
   g. What will be the velocity of the ball when it is 8,950 m above the surface of the Earth?
   h. How long will it take for the ball to be 8,950 m above the surface of the Earth?
   i. What will be the velocity of the ball just before it strikes the ground?
   j. What is the total distance the ball travels during the first 4.5 s?
   k. What is the total distance the ball travels?
   l. How long will it take for the ball to be 300 m above the surface of the Earth?
   m. Draw a displacement vs. time graph, a velocity vs. time graph, and an acceleration vs. time graph for the ball.

4. Noah drops a ball from rest at an elevation 830 m above the surface of the Earth.
   a. What will be the acceleration of the ball (number and direction) at the moment it is dropped?
   b. What will be the acceleration of the ball (number and direction) when it is 415 m above the surface of the Earth?
   c. What will be the acceleration of the ball (number and direction) just before it strikes the surface of the Earth?
   d. How long will it take for the ball to be 415 m above the surface of the Earth?
   e. What will be the velocity of the ball 415 m above the surface of the Earth?
   f. What will be the velocity of the ball just before it strikes the ground?
   g. What is the total distance the ball travels during the first 8 s?
   h. How long will it take for the ball to be 300 m above the surface of the Earth?
   i. What is the average speed of the ball?
   j. Draw a displacement vs. time graph, a velocity vs. time graph, and an acceleration vs. time graph for the ball.

5. Eber throws a ball vertically downwards with an initial speed of 22 m/s from a height of 8,848 m above the surface of the Earth.
   a. What will be the acceleration of the ball (number and direction) at the moment after it is thrown downwards?
   b. What will be the acceleration of the ball (number and direction) just before it strikes the surface of the Earth?
   c. What will be the velocity of the ball just before it strikes the surface of the Earth?
   d. How long will it take for the ball to reach the surface of the Earth?
   e. What will be the velocity of the ball when it is 4,000 m above the surface of the Earth?
   f. How long will it take for the ball to reach 4,000 m above the surface of the Earth?
   g. What is the total distance the ball travels after 12.5 s?
   h. Draw a displacement vs. time graph, a velocity vs. time graph, and an acceleration vs. time graph for the ball.

6. Salah throws a ball with an initial speed of 47 m/s at an angle of 30° north of east 830 meters above the surface of the Earth.
   a. Complete the table:

$x_i =$	$y_i =$
$v_{i,x} =$	$v_{i,y} =$
$a_x =$	$a_y =$

   b. What will be the horizontal velocity and horizontal acceleration of the ball (number and direction) when it reaches its maximum height?
   c. What will be the vertical velocity and vertical acceleration of the ball (number and direction) when it reaches its maximum height?
   d. How long will the ball be in the air for?
   e. What will be the range of the ball?
   f. What will be the maximum height of the ball from the surface of the Earth after it is thrown?
   g. How long will it take for the ball to reach its maximum height after it is thrown?
   h. How long does it take for the ball to reach 400 m above the surface of the Earth after it is thrown?
   i. How high above the surface of the Earth will the ball be eight seconds after it is thrown?
   j. How far horizontally does the ball travel during the first eight seconds after it is thrown?
   k. What will be the velocity of the ball (number and direction) eight seconds after it is thrown?
   l. What will be the displacement of the ball (number and direction) eight seconds after it is thrown?
   m. Draw an acceleration vs. time graph, a velocity vs. time graph, a speed vs. time graph, a displacement vs. time graph, and a distance vs. time graph for the ball for both the horizontal direction and the vertical direction.

7. Abraham throws a ball horizontally eastward with an initial speed of 22 m/s from 830 meters above the surface of the Earth.
   a. Complete the table:

$x_i =$	$y_i =$
$v_{i,x} =$	$v_{i,y} =$
$a_x =$	$a_y =$

   b. How long will the ball be in the air for after it is thrown?
   c. What will be the range of the ball?
   d. How long does it take for the ball to reach 400 m above the surface of the Earth after it is thrown?
   e. How high above the surface of the Earth will the ball be eight seconds after it is thrown?
   f. How far horizontally does the ball travel during the first eight seconds after it is thrown?
   g. What will be the velocity of the ball (number and direction) eight seconds after it is thrown?
   h. What will be the displacement of the ball (number and direction) eight seconds after it is thrown?

8. Lot throws a ball at an initial speed of 12 m/s at an angle of 30° south of east from 830 meters above the surface of the Earth.
   a. Complete the table:

$x_i =$	$y_i =$
$v_{i,x} =$	$v_{i,y} =$
$a_x =$	$a_y =$

   b. How long will the ball be in the air for?
   c. What will be the range of the ball?
   d. How long after the ball is thrown does it take to reach 400 m above the surface of the Earth?
   e. How high above the surface of the Earth will the ball be four seconds after it is thrown?
   f. How far horizontally does the ball travel during the first four seconds after it is thrown?
   g. What will be the velocity of the ball (number and direction) four seconds after it is thrown?
   h. What will be the displacement of the ball (number and direction) four seconds after it is thrown?

9. A 25 kg ball is thrown from the edge of a very tall building with an initial speed of 20 m/s at an angle of 60° north of east. There is an infinitely tall vertical wall 120 m from the building.
   a. Draw a figure.

   b. Complete the table:

$x_i =$	$y_i =$
$v_{i,x} =$	$v_{i,y} =$
$a_x =$	$a_y =$

   c. How much time does it take for the ball to hit the wall after it is thrown?
   d. At which height above or below the original position where the ball is thrown will the ball hit the wall?
   e. What will be the velocity of the ball (number and direction) when it hits the wall?
   f. What will be the displacement of the ball (number and direction) when it hits the wall?

Name: _____

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2.2 – Forces

Understandings:

- Objects as point particles
- Free-body diagrams
  http://hyperphysics.phy-astr.gsu.edu/hbase/N2st.html#c1
  https://openstax.org/books/university-physics-volume-1/pages/5-7-drawing-free-body-diagrams
- Translational equilibrium (aka dynamic equilibrium)
  http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
- Newton's laws of motion
  http://hyperphysics.phy-astr.gsu.edu/hbase/Newt.html#ntcon
  https://openstax.org/books/university-physics-volume-1/pages/5-introduction
- Solid friction
  http://hyperphysics.phy-astr.gsu.edu/hbase/frict.html#fri
  https://openstax.org/books/university-physics-volume-1/pages/6-2-friction

Equations

$$\sum \vec{F}_{ext} = m\vec{a}$$

$$\vec{F}_f \leq \mu_s F_n$$

$$\vec{F}_f = \mu_d F_n$$

Equation not given in IB Physics Data Booklet

$$\vec{F}_{spring} = -k \times \Delta\vec{x}$$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Answer the following questions.

1. What is the meaning and equation of *directly proportional*? *Inversely proportional*? Give an example of each.
   https://www.mathsisfun.com/algebra/directly-inversely-proportional.html

2. What is *mass*? What are its units? Is it a scalar or vector?
   http://hyperphysics.phy-astr.gsu.edu/hbase/mass.html#mas

3. What is a *force*? What are its units? Is it a scalar or vector? How many objects are required for a *force*?
   http://hyperphysics.phy-astr.gsu.edu/hbase/Newt.html#ntcon

4. What is the *force of gravity*? This is also called *weight*.
   http://hyperphysics.phy-astr.gsu.edu/hbase/mass.html#mas

5. What are the equations for the *force of gravity*
   a. if we are near the surface of a planet? Draw an image.
      http://hyperphysics.phy-astr.gsu.edu/hbase/mass.html#mas

   b. in general (this is called *Newton's Law of Gravitation*)? Draw an image.
      http://hyperphysics.phy-astr.gsu.edu/hbase/grav.html#grav

6. What are some differences between *mass* and *weight*?
   http://hyperphysics.phy-astr.gsu.edu/hbase/mass.html

7. What is the *normal force*? In which direction does it point? Draw an image.
   http://hyperphysics.phy-astr.gsu.edu/hbase/frict.html

8. What is the *force of friction*? In which direction does it point? Draw an image.
   http://hyperphysics.phy-astr.gsu.edu/hbase/frict.html

9. What is the equation for *surface friction*? Define each variable.
   http://hyperphysics.phy-astr.gsu.edu/hbase/frict.html

10. What is the meaning of *kinetic*? *Static*? Which is greater: *kinetic friction* or *static friction*?
    www.dictionary.com

11. What is the meaning of a *rough surface*? A *smooth surface*?

12. For which object do we use the *force of tension*? Draw an image.
    http://hyperphysics.phy-astr.gsu.edu/hbase/mlif.html

13. What is the equation for the *spring force*? Define each variable. What is the meaning and units for the *spring constant k*? What is the name and meaning of the minus sign? This is called *Hooke's Law*. Draw an image.
http://hyperphysics.phy-astr.gsu.edu/hbase/pespr.html

14. Draw a *force vs. displacement* graph for a mass on a spring. What does the slope of a *force vs. displacement* graph tell us? What does the area under a *force vs. displacement* graph tell us?
http://hyperphysics.phy-astr.gsu.edu/hbase/pespr.html

15. What is the *buoyant force*? Draw an image.
http://hyperphysics.phy-astr.gsu.edu/hbase/pbuoy.html#buoy

16. How do we draw a *free body diagram*? Here are the steps:
    a. Circle the object (or objects) in question
    b. Label all the external/outside forces on the object (or objects) with an arrow to show the direction and magnitude of each force
    c. Draw a convenient axis to minimize vector components
    d. For each object apply Newton's second law of motion for each axis
    http://hyperphysics.phy-astr.gsu.edu/hbase/freeb.html#fb

17. What is the meaning of *inertia*? What is *inertia* directly proportional to?
http://hyperphysics.phy-astr.gsu.edu/hbase/mass.html#mas
https://www.physicsclassroom.com/class/newtlaws/Lesson-1/Inertia-and-Mass

18. State the name of *Newton's first law of motion*. State the definition/meaning of *Newton's first law of motion*.
http://hyperphysics.phy-astr.gsu.edu/hbase/Newt.html

19. Why is it not safe to stand up when a bus, plane, or subway is moving?

20. State the name of *Newton's second law of motion*. State the equation for *Newton's second law of motion*.

21. True or false:
    a. According to Newton's second law of motion $\sum \vec{F}$ and $\vec{a}$ will always point in the same direction.

    b. According to Newton's second law of motion $\sum \vec{F}$ and $\vec{v}$ will always point in the same direction. In other words, there must be a net force in the same direction as the motion of the object.

    c. According to Newton's second law of motion $\vec{v}$ and $\vec{a}$ will always point in the same direction.

22. Give an example of an object when its net force (or acceleration) and velocity point in opposite directions. Draw an image and label the direction of velocity, force, and acceleration.

23. What is the meaning of *static equilibrium*? What is the meaning of *translational/dynamic equilibrium*? https://openstax.org/books/college-physics/pages/9-1-the-first-condition-for-equilibrium

24. State the name of *Newton's third law of motion*. State the equation for *Newton's third law of motion*.

25. Give three examples of *Newton's third law of motion* (For each example you need two sentences: one for the action and one for the reaction.). Three examples have been given to you:
    a. Man pushes wall forward. Wall pushes man backwards.
    b. Fish pushes water backwards. Water pushes fish forwards.
    c. Earth pulls man down. Man pulls Earth up.
    d.
    e.
    f.

26. **Use a pencil and ruler!** Define *free fall*. Draw a *displacement vs. time* graph, a *distance vs. time* graph, a *velocity vs. time* graph, a *speed vs. time* graph, and an *acceleration vs. time* graph for an object dropped from rest in free fall. http://hyperphysics.phy-astr.gsu.edu/hbase/traj.html#ffall

27. **Use a pencil and ruler!** Define *terminal velocity*. What is the relationship between speed and the force of friction? Draw a *distance vs. time* graph, a *speed vs. time* graph, and an *acceleration vs. time* graph of an object being dropped from rest from a very high elevation above the surface of the Earth with both the force of friction and the force of gravity acting on it.
https://openstax.org/books/university-physics-volume-1/pages/6-4-drag-force-and-terminal-speed
http://hyperphysics.phy-astr.gsu.edu/hbase/lindrg.html
http://hyperphysics.phy-astr.gsu.edu/hbase/airfri2.html#c1

Name: _____

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2.2 - Free Body Diagrams

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

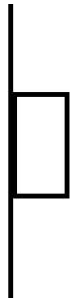
Use a pencil and ruler! Draw free body diagrams.

http://hyperphysics.phy-astr.gsu.edu/hbase/N2st.html#c1

1. A block is at rest on a horizontal surface.

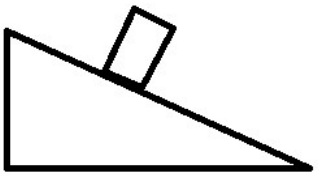
2. A man is pushing a block to the left with a horizontal force on a rough horizontal surface. The block does not move.

3. An object is being pushed to the left on a wall. The object does not move.

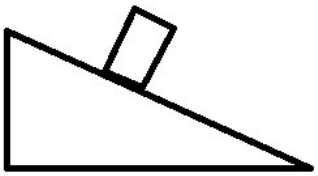


4. A man is pushing a block on a slope which is 20° from the horizontal on a rough horizontal surface. The block does not move.

The man is pushing the block downwards parallel to the surface.

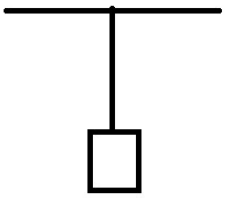


The man is pushing the block upwards parallel to the surface.

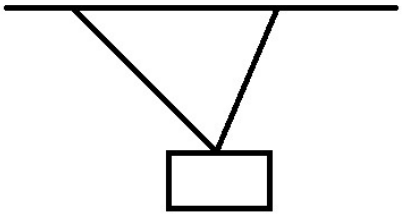


5. A dead fish is floating on top of the plastic radioactive ocean water.

6. A block is at rest and is hanging from the ceiling by one massless string.

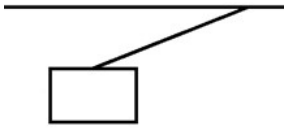


7. A block is at rest and is hanging from the ceiling by two massless strings.

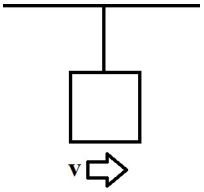


8. A block is tied to a massless string and is raised up at an angle θ from the vertical.

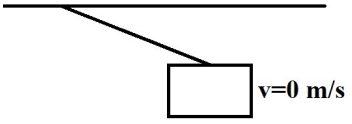
The block is released from rest.



The block is now at the bottom of its motion.



The block is now at the top of its motion.



9. A car is moving in a straight line to the right with a constant speed

on a smooth horizontal surface.

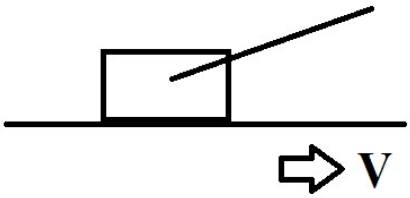
on a rough horizontal surface.

10. A car is moving in a straight line to the right on a rough horizontal surface.

The car is slowing down (decelerating).

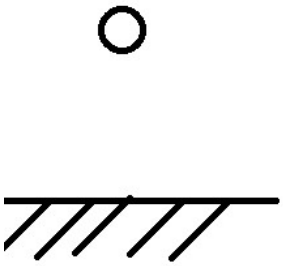
The car is speeding up (accelerating).

11. A man pulls a massless string which is attached to a block with a constant speed at an angle θ above the horizontal on a rough surface. Label the forces on the block, not the man.

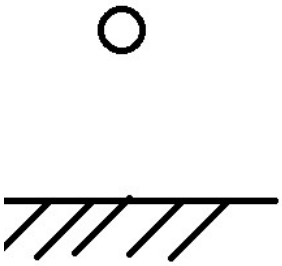


12. A ball is thrown vertically up and is moving upwards. The ball is halfway to the top.

There is **no** force of air friction.

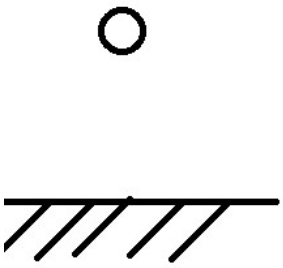


There **is** a force of air friction.

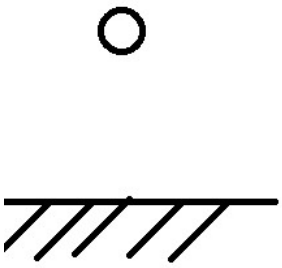


13. A ball is thrown vertically up and is at its maximum height.

There is **no** force of air friction.

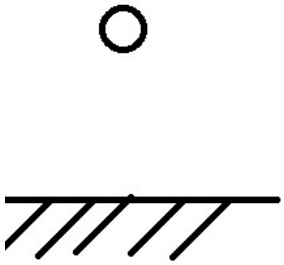


There **is** a force of air friction.

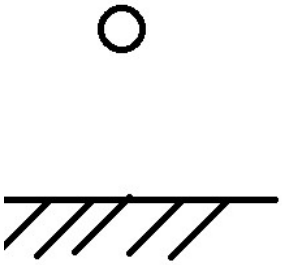


14. A ball is **dropped** from rest from the top of a very tall building. There is no force of air friction. Draw a free body diagram of the ball ….

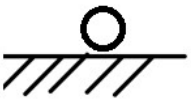
the moment the ball is dropped.



when the ball is halfway down.

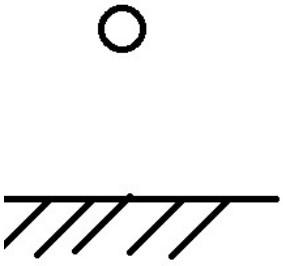


just before ball strikes the ground.

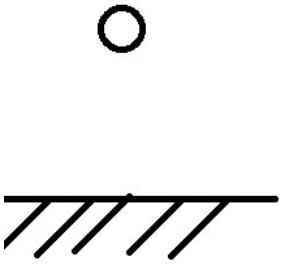


15. A ball is **thrown** downwards from the top of a tall building. Draw a free body diagram of the ball when the ball is halfway down when….

there is **no** force of air friction.

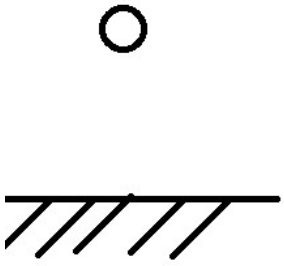


there **is** a force of air friction.

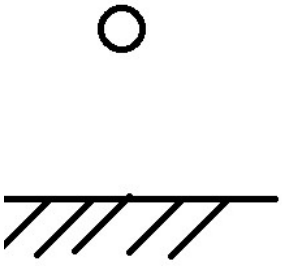


16. A ball is released from rest from the top of a very tall building. There is air friction. Draw a free body diagram of the ball….

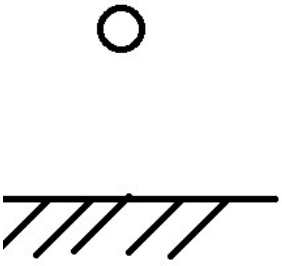
a few seconds before the ball reaches its terminal velocity.



the exact moment the ball reaches its terminal velocity.

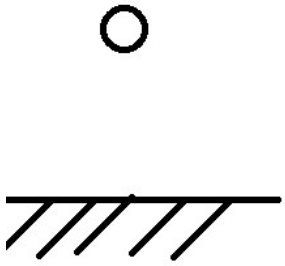


a few seconds after the ball reaches its terminal velocity.

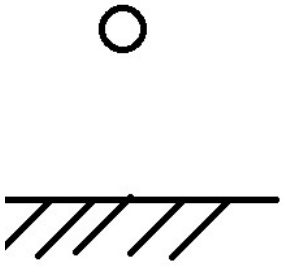


17. A ball is thrown at an angle $\theta = 45°$ north of east from a horizontal surface. Draw a free body diagram of the ball the moment it is thrown if ….

there is **no** force of air friction.

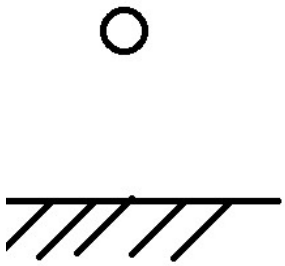


there **is** a force of air friction.

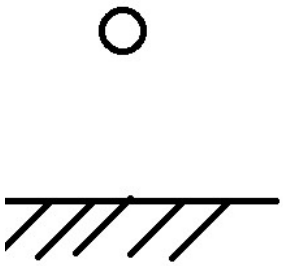


18. A ball is thrown at an angle $\theta = 45°$ north of east from a horizontal surface. The ball is at its maximum vertical height.

There is **no** force of air friction.

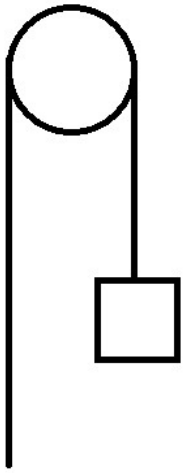


There **is** a force of air friction.

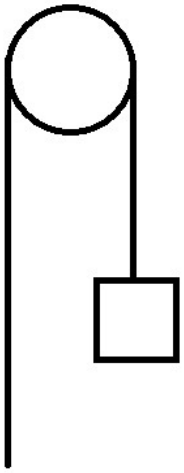


19. A block is being pulled vertically upwards by a massless string pulley.

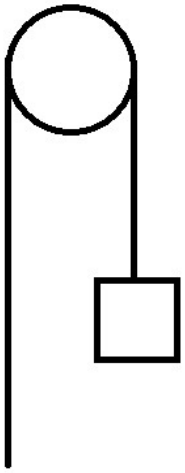
The speed of the block is constant and moving upwards.



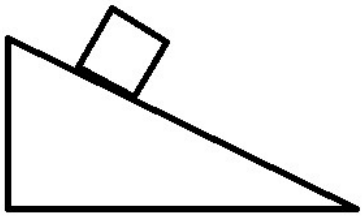
The block is accelerating upwards.



The block is slowing down and moving upwards (decelerating).

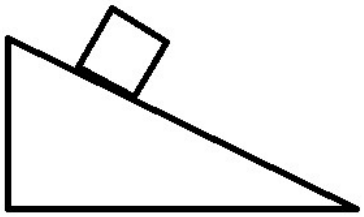


20. A block is at rest on an incline. There is surface friction.

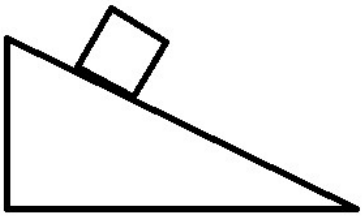


21. A block moves down an incline. There is surface friction.

The speed of the block is constant.

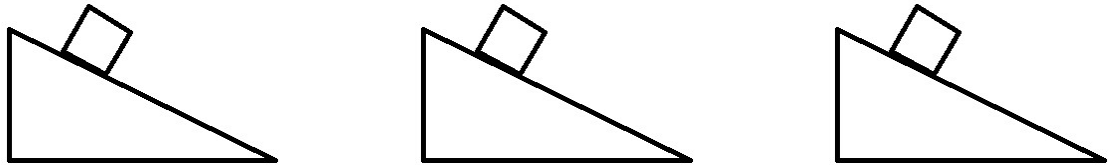


The block accelerates.

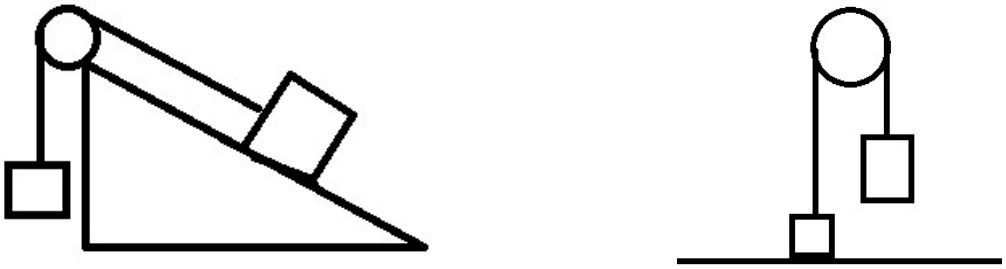


22. A block is pushed up an incline parallel to the surface. There is surface friction.

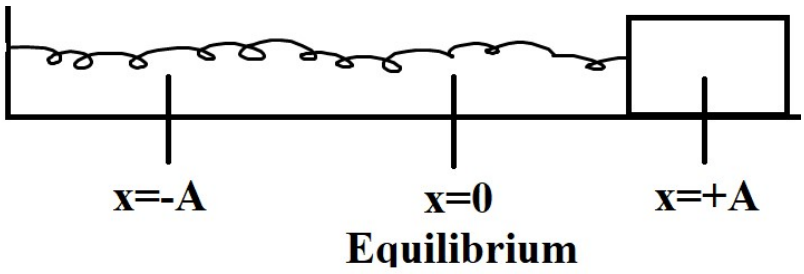
The block slows down (decelerates).	The speed of the block is constant.	The block speeds up (accelerates).



23. Two blocks are attached to each other by a common string. There is surface friction.



24. A mass lying on a rough horizontal surface is attached to a spring and is stretched from its equilibrium position. It is then released.



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2.2 – Applying Newton's Second Law

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Answer the following questions

http://hyperphysics.phy-astr.gsu.edu/hbase/N2st.html#c1

1. A 14 kg mass is at rest on a horizontal surface.

   a. Draw a free body diagram.
   b. What is the force of gravity acting on the object?
   c. What is the normal force acting on the object?

2. Ishmael pushes a 16 kg block to the left on a rough horizontal surface with a force of 70 N. The block does not move.

   a. Draw a free body diagram.
   b. What is the force of gravity acting on the object?
   c. What is the normal force acting on the object?
   d. What is the force of friction exerted on the block?
   e. What is the coefficient of static friction?

3. Isaac pushes a 18 kg block to the left on a smooth horizontal surface with a force of 70 N.

   a. Draw a free body diagram.
   b. What is the force of gravity acting on the object?
   c. What is the normal force acting on the object?
   d. What is the horizontal acceleration of the block?
   e. What is the vertical acceleration of the block?

4. Jacob pushes a 20 kg block to the left on a rough horizontal surface with a force of 70 N. The block moves at a constant speed of 2 m/s.

   a. Draw a free body diagram.
   b. What is the force of gravity acting on the object?
   c. What is the normal force acting on the object?
   d. What is the horizontal acceleration of the block?
   e. What is the vertical acceleration of the block?
   f. What is the force of friction exerted on the block?
   g. What is the coefficient of dynamic friction μ between the block and the surface?

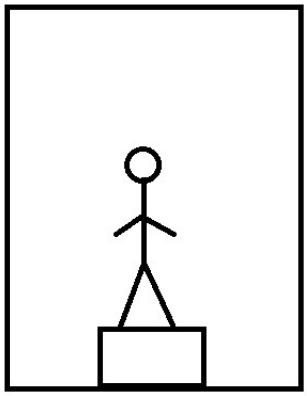
5. Adam pushes a block with a mass of 24 kg to the right on a rough horizontal surface with a coefficient of kinetic friction of 0.3. The block moves with a constant acceleration of 2 $\frac{m}{s^2}$.

a. Draw a free body diagram.
b. What is the force of gravity acting on the object?
c. What is the normal force acting on the object?
d. What is the force of friction exerted on the block?
e. What is the force of push given to the block?

6. Joseph is pulling a 65 kg block with a force of 800 N at an angle of 45 degrees north of east above the horizontal of a rough horizontal surface. The coefficient of friction between the block and the surface is $\mu = 0.3$.

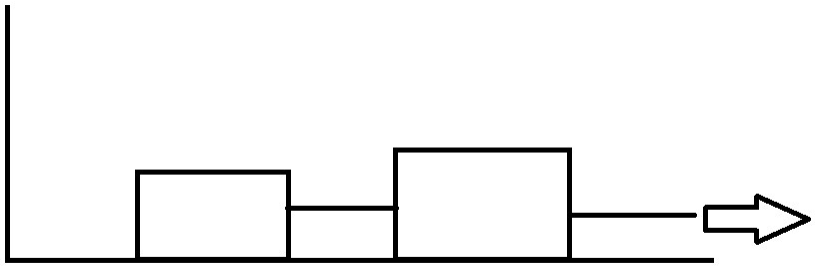
   a. Draw a free body diagram.
   b. What is the vertical acceleration of the block?
   c. What is the normal force acting on the block?
   d. What is the horizontal acceleration of the block?

7. An 80 kg man is standing on a scale in an elevator.



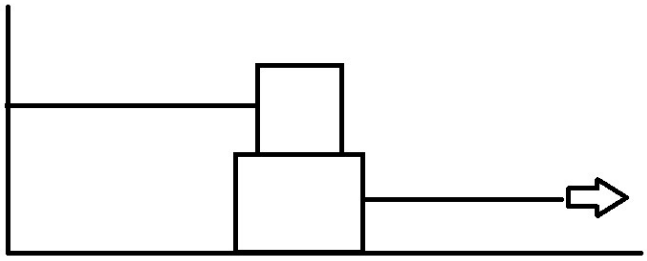
Determine the reading on the scale when
a. the elevator is at rest.
b. the elevator is moving up with a constant speed of 2 m/s.
c. the elevator is moving down with a constant speed of 2 m/s.
d. the elevator moves upwards with a constant acceleration of 2 m/s^2.
e. the elevator moves downwards with a constant acceleration of 2 m/s^2.

8. A block with a mass $m_2 = 20\ kg$ is on a rough horizontal surface with a coefficient of friction of $\mu = 0.4$. Attached to the right of m_2 is a massless string which is pulling m_2 to the right with a force of tension $F_{tension}$. Attached to the right of the massless string is another block of mass $m_1 = 30\ kg$. Attached to the right of m_1 is another massless string which pulls the whole system with a constant pulling force $F_{pull} = 800\ N$ and constant acceleration a.



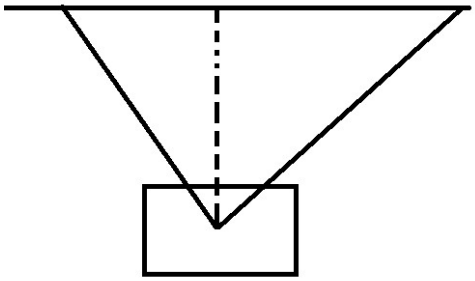
a. Draw a free body diagram.
b. Find the horizontal acceleration of the whole system a.
c. Find the force of tension $F_{tension}$ of the massless string which attaches both masses.

9. A block with a mass $m_2 = 15\ kg$ is on a rough horizontal surface. There is a string pulling it to the right with a force F_{pull} at a constant speed. Above m_2 there is a block with a mass $m_1 = 12\ kg$. There is a string attached to the left of m_1 which is attached to a wall which has a force of tension $F_{tension}$. The coefficient of friction between m_1 and m_2 is $\mu_{1,2} = 0.25$ and the coefficient of friction between m_2 and the surface is $\mu_{2,surface} = 0.35$.



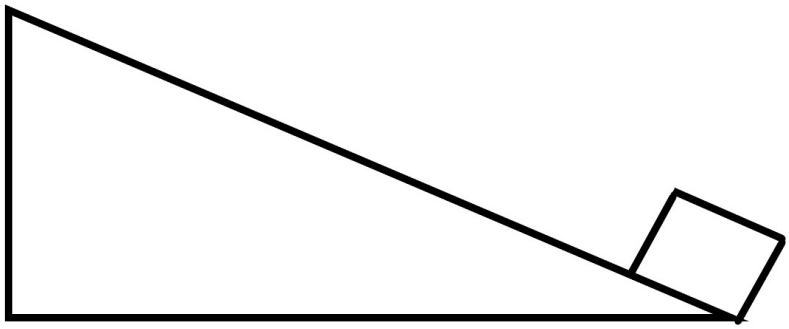
a. Draw a free body diagram.
b. Find $F_{tension}$.
c. Find F_{pull}.

10. A 12 kg block is held at rest in the air by two strings attached to a wall. The first string makes an angle of $\theta_1 = 60°$ north of west. The second string makes an angle of $\theta_2 = 45°$ north of east.



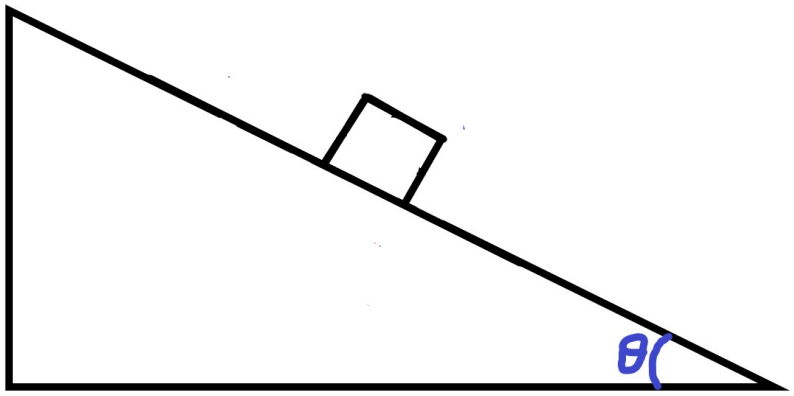
a. Draw a free body diagram.
b. Find the force of tension on each string.

11. A block with mass 15 kg is at rest on the bottom of an incline with $\theta = 25°$ which is 35 m long. The coefficient of friction between the block and the surface is $\mu = 0.45$. A man pushes the block up parallel to the incline with a force of 155 N.



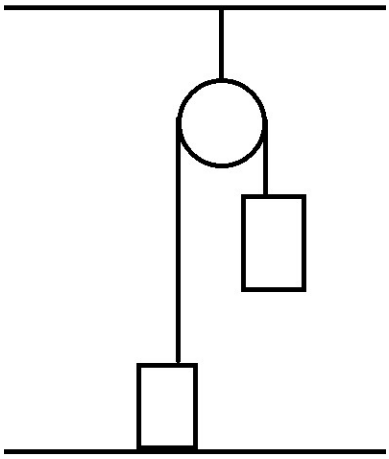
a. Draw a free body diagram.
b. What is the acceleration of the block?
c. What will be the final speed of the block when it reaches the top of the incline?
d. How long will it take for the block to reach the top of the incline?

12. A block with mass 65 kg is initially at rest in the middle of an incline with $\theta = 25°$ which is 40 m long. The coefficient of friction between the block and the surface is $\mu = 0.45$. A man pushes the block down parallel to the incline with a force of 60 N. The block accelerates downwards at a constant rate.



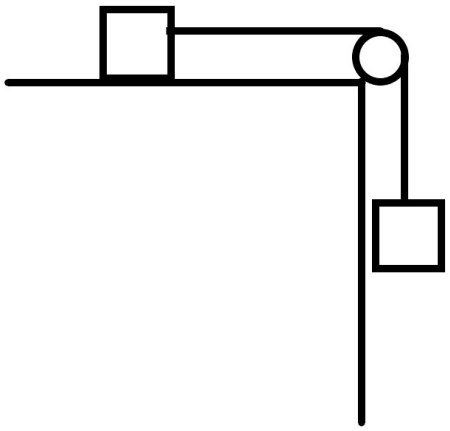
a. Draw a free body diagram.
b. What is the magnitude of the acceleration of the block?
c. What will be the final speed of the block when it reaches the bottom of the incline?
d. How long will it take for the block to reach the bottom of the incline?

13. A massless frictionless pulley is attached to a ceiling. Mass $m_1 = 16\ kg$ is initially held at rest on the ground. It is attached to a massless string which goes over the massless frictionless pulley and is attached to another mass $m_2 = 46\ kg$ which is also initially at rest in the air as shown in the figure below. Mass m_1 is released from rest and both masses accelerate at a constant rate.



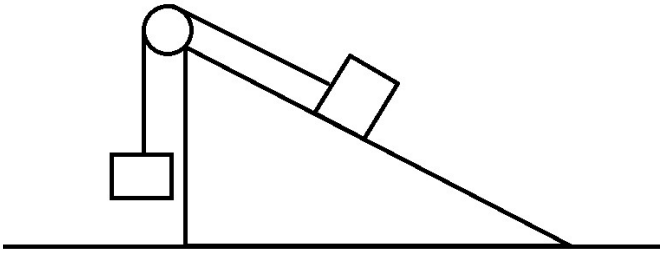
a. Draw a free body diagram.
b. Find the common acceleration of the two masses.
c. Find the force of tension $F_{tension}$ of the massless string.

14. A block of mass $m_1 = 12\ kg$ sits at rest on a horizontal surface with $\mu = 0.24$. Mass m_1 is attached to a massless string which goes over a massless frictionless pulley which is attached to another block of mass $m_2 = 36\ kg$.



a. Draw a free body diagram.
b. What is the common acceleration of the blocks?
c. What is the force of tension on the string?

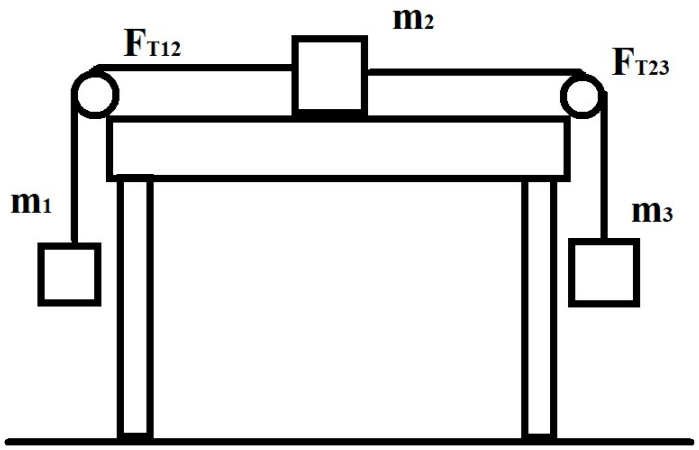
15. A 4 kg mass m_1 is initially at rest on a $\theta = 30°$ incline. The surface has a coefficient of friction $\mu = 0.4$. The 4 kg mass has a massless string attached to it which goes over the top of the incline above a frictionless pulley to another mass m_2 of 18 kg which is hanging in the air. Both objects are released from rest and move with a constant acceleration. m_2 moves down while m_1 moves up the incline.



a. Draw a free body diagram:
b. What will be the common acceleration of the two masses?
c. What will be the force of tension on the string?

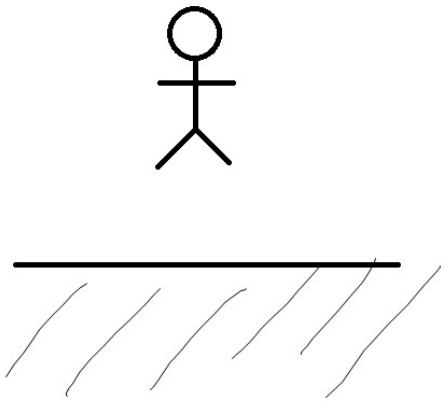
16. A block with mass $m_2 = 8\ kg$ is held at rest on a rough horizontal table which has a coefficient of friction of $\mu = 0.2$. It is attached by a string to a mass $m_3 = 14\ kg$ which hangs to the right of the table and another string to a mass $m_1 = 2\ kg$ which hangs to the left of table as shown below. Mass m_2 is released from rest and the whole system accelerates with a constant rate.

    a. Draw a free body diagram.
    b. Determine the acceleration of the system.
    c. Determine the force of tension of string F_{T12} and the force of tension of string F_{T2} .



17. An 80 kg man on Earth jumps vertically upwards. The acceleration due to gravity near the surface of the Earth is approximately $9.81\ m/s^2$. The mass of the Earth is approximately $5.97 \times 10^{24}\ kg$. Use Newton's third law of motion to determine the acceleration of the Earth from the man after the man jumps.

    Apart from dark matter and antimatter, physicists have discovered a new type of matter called "doesn't matter" which seems to have no effect whatsoever.



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2.3 – Work Energy Power

Understandings

- Kinetic energy
  http://hyperphysics.phy-astr.gsu.edu/hbase/ke.html#ke
- Gravitational potential energy
  http://hyperphysics.phy-astr.gsu.edu/hbase/gpot.html#mgh
- Elastic potential energy
  http://hyperphysics.phy-astr.gsu.edu/hbase/pespr.html#pe2
- Work done as energy transfer
  http://hyperphysics.phy-astr.gsu.edu/hbase/work.html#wepr
- Power as rate of energy transfer
  http://hyperphysics.phy-astr.gsu.edu/hbase/pow.html#pwc
- Principle of conservation of energy
  http://hyperphysics.phy-astr.gsu.edu/hbase/conser.html#coneng
- Efficiency
  https://www.softschools.com/formulas/physics/efficiency_formula/29/

Equations

$$W = Fd\cos\theta$$

$$KE = \frac{1}{2}mv^2$$

$$PE = \frac{1}{2}kx^2$$

$$GPE = mgh$$

$$P = Fv$$

$$Efficiency = \frac{useful\ work\ out}{total\ work\ in} = \frac{useful\ power\ out}{total\ power\ in}$$

Equation not given in IB Physics Data Booklet

$$W = \Delta KE = KE_f - KE_i$$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. What is the meaning of *work*? Equation? Define each variable. Units? Is it a scalar or vector?
   http://hyperphysics.phy-astr.gsu.edu/hbase/wcon.html

2. What is the meaning of *energy*? Units? Is it a scalar or vector?
   http://hyperphysics.phy-astr.gsu.edu/hbase/enecon.html

3. What is the meaning of *kinetic energy*? Equation? Define each variable.
   http://hyperphysics.phy-astr.gsu.edu/hbase/ke.html#ke

4. What will happen to the kinetic energy of a moving object if its
   a. mass halves and speed halves?

   b. mass doubles and speed doubles?

   c. mass decreases by three (one third) and speed increases by four (quadruples)?

5. What is the meaning of *potential energy*?
   http://hyperphysics.phy-astr.gsu.edu/hbase/pegrav.html#pe

6. What is the meaning of *gravitational potential energy*? What is the equation for *gravitational potential energy* of an object near the surface of a planet? Define each variable. What is the general equation for the *gravitational potential energy* between two objects? Define each variable.
http://hyperphysics.phy-astr.gsu.edu/hbase/gpot.html#mgh
http://hyperphysics.phy-astr.gsu.edu/hbase/gpot.html#ufm

7. What is the equation for the *potential energy* of a compressed or stretched spring? Define each variable. What is the meaning and what are the units for the *spring constant k*?
http://hyperphysics.phy-astr.gsu.edu/hbase/pegrav.html#pe
http://hyperphysics.phy-astr.gsu.edu/hbase/pespr.html#pe2

8. What is the equation for the *total mechanical energy* of an object?
https://openstax.org/books/physics/pages/9-2-mechanical-energy-and-conservation-of-energy

9. True or false: Work is done on an object if the object moves.
http://hyperphysics.phy-astr.gsu.edu/hbase/wcon.html

10. What is the work done on a 3 kg rock if it travels 60 m with a constant speed of 4 m/s in outer space?

11. What are the units of the slope of a *force vs. displacement* graph? What does the slope of a *force vs. displacement* graph tell us?

12. What are the units of the area under a *force vs. displacement* graph? What does the area under a *force vs. displacement* graph tell us?
http://hyperphysics.phy-astr.gsu.edu/hbase/pespr.html

13. What is the meaning of *power P*? Equation? Units? Is it a scalar or vector? Do not confuse power P with pressure P or momentum $\vec{p}$ or density ρ!
http://hyperphysics.phy-astr.gsu.edu/hbase/powcon.html

14. What is the meaning of and the equation for the *law of conservation of energy*?
http://hyperphysics.phy-astr.gsu.edu/hbase/conser.html#isosys

15. What is *efficiency*? Equation? Units? Is it a scalar or vector?
https://openstax.org/books/physics/pages/9-3-simple-machines

Part 2: Answer the following questions

Round all your answers to two decimal points. Let the magnitude of the acceleration from gravity near the surface of the Earth be $\vec{g} = 9.81\ m/s^2$.

1. Job pulls a massless rope at an angle of 40° from the horizontal which is attached to a block of mass $m = 60\ kg$ on a rough horizontal surface with a coefficient of friction of $\mu = 0.2$ with a constant speed of 2 m/s for 300 m.
   a. Draw a free body diagram.
   b. Use Newton's second law of motion to find F_{pull}.
   c. How much work was done by Job?
   d. What is the average power performed by Job?

2. A 10 kg object initially at rest is 12 m above the surface of the Earth. It is released. There is no air friction.
   a. Draw a figure.
   b. What is the initial kinetic energy of the object?
   c. What is the initial gravitational potential energy of the object?
   d. What is the initial total energy of the object?
   e. What is the kinetic energy of the object when it is halfway to the surface?
   f. What is the gravitational potential energy of the object when it is halfway to the surface?
   g. What is the total energy of the object when it is halfway to the surface?
   h. What is the final gravitational potential energy of the object just before it reaches the surface?
   i. What is the final kinetic energy of the object just before it reaches the surface?
   j. What is the total energy of the object just before it reaches the surface?
   k. What is the final speed of the object just before it reaches the ground?
   l. Draw a *gravitational potential energy vs. height* graph, a *kinetic energy vs. height* graph, and a *total energy vs. height* graph.

3. Jethro throws a 5 kg object from the surface of the Earth vertically upwards with an initial speed of 8 m/s. There is no air friction.
   a. Draw a figure.
   b. What is the initial gravitational potential energy of the object?
   c. What is the initial kinetic energy of the object?
   d. What is the initial total energy of the object?
   e. What is the maximum height the object will travel?
   f. How long will it take for the object to reach its maximum height?
   g. What is the gravitational potential energy of the object when it is halfway to its maximum height?
   h. What is the kinetic energy of the object when it is halfway to its maximum height?
   i. What is the total energy of the object when it is halfway to its maximum height?
   j. What is the gravitational potential energy of the object when it reaches its maximum height?
   k. What is the kinetic energy of the object when it reaches its maximum height?
   l. What is the total energy of the object when it reaches its maximum height?
   m. What is the speed of the object when it reaches its maximum height?
   n. Draw a *gravitational potential energy vs. height* graph, a *kinetic energy vs. height* graph, and a *total energy vs. height* graph.

4. A 8 kg object is falling vertically freely with a speed of 40 m/s at an elevation of h_1. What will be the speed of the object after it has fallen a distance of 70 m? Round your answer to two decimal places.

5. A 8 kg object is falling down with a speed of 40 m/s at an elevation of 300 m. After the object has fallen a distance of 90 m its speed is now 45 m/s.
   a. What is the magnitude of energy lost from air friction? Round your answer to two decimal places.
   b. What is the magnitude of the force of air friction during this 90 m? Round your answer to two decimal places.

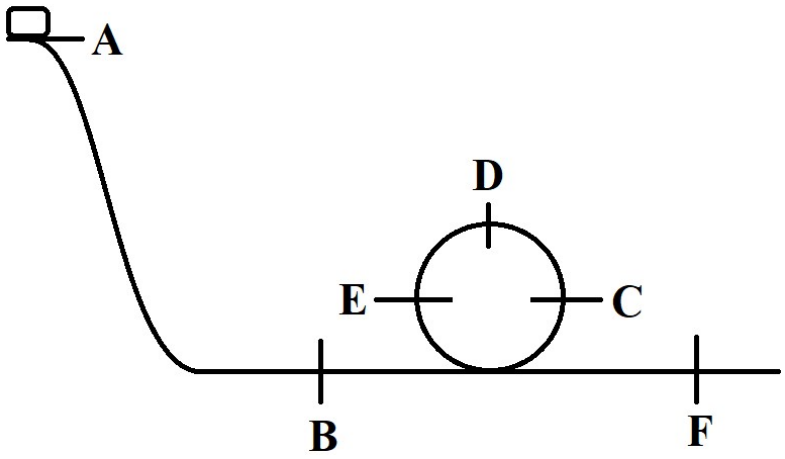
6. A 7 kg object is placed on a 12 m long smooth incline which is 30° above the horizontal. It is released and slides down.
   a. Draw a figure.
   b. What is the initial height of the object?
   c. What is the initial gravitational potential energy of the object?
   d. What is the initial kinetic energy of the object?
   e. What is the initial total energy of the object?
   f. What is the final speed of the object when it reaches the bottom of the incline?
   g. What is the final kinetic energy of the object?
   h. What is the final gravitational potential energy of the object?
   i. What is the acceleration of the object?
   j. How long does it take for the object to reach the bottom of the incline?

7. A 4 kg block is placed on a 20 m long rough incline which is 30° above the horizontal. The coefficient of friction between the block and the incline is $\mu = 0.3$. The block is released and slides down.
   a. Draw a figure.
   b. What is the initial height of the object?
   c. What is the initial gravitational potential energy of the object?
   d. What is the initial kinetic energy of the object?
   e. What is the initial total energy of the object?
   f. What is the normal force F_{normal} acting on the block?
   g. What is the force of friction $F_{friction}$ acting on the block?
   h. What is the final speed of the object when it reaches the bottom of the incline?
   i. What is the acceleration of the block?
   j. What is the final kinetic energy of the object?
   k. What is the final gravitational potential energy of the object?
   l. What is the final total energy of the block?
   m. How long does it take for the object to reach the bottom of the incline?
   n. How much energy was lost by the block?

8. A 6 kg block is moving to the right with a constant speed of 22 m/s on a horizontal frictionless surface. The block then goes up a 30° incline which has a coefficient of friction of 0.8.
   a. Draw a figure.
   b. How high does the block move up the incline?
   c. How many meters up the incline does the block move up?

9. A horizontal spring with a spring constant $k = 3{,}000\ N/m$ is compressed 6 cm by an 800 gram block which is resting on a frictionless surface. The block is then released from rest.
   a. Draw a figure.
   b. What is the initial potential energy of the spring?
   c. What is the kinetic energy of the block after it leaves the spring?
   d. What is the final speed of the block after it leaves the spring?
   e. After some distance the block moves through a rough surface with a coefficient of friction μ=0.05. What is the total distance the block travels along the rough surface?

10. A 425 kg roller coaster begins from rest at a height $h_1 = 140\ m$ above the surface of the Earth. The roller coaster makes a circular loop with a radius of $r = 24\ m$.



a. Determine the total energy of the roller coaster at points A, B, C, D, E, and F. Write neatly, show all your work, and place a box around all six of your answers.
b. Determine the gravitational potential energy of the roller coaster at points A, B, C, D, E, and F. Write neatly, show all your work, and place a box around all six of your answers.
c. Determine the kinetic energy of the roller coaster at points A, B, C, D, E, and F. Write neatly, show all your work, and place a box around all six of your answers.
d. Determine the speed of the roller coaster at points A, B, C, D, E, and F. Write neatly, show all your work, and place a box around all six of your answers.

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2.4 – Momentum and Impulse

Understandings

- Newton's second law expressed in terms of rate of change of momentum https://openstax.org/books/university-physics-volume-1/pages/9-2-impulse-and-collisions
- Impulse and force-time graphs http://hyperphysics.phy-astr.gsu.edu/hbase/impulse.html#c1
- Conservation of linear momentum https://openstax.org/books/university-physics-volume-1/pages/9-3-conservation-of-linear-momentum
- Elastic collisions, inelastic collisions, and explosions https://openstax.org/books/university-physics-volume-1/pages/9-4-types-of-collisions

Equations

$\vec{p} = m\vec{v}$ Equation not given in IB Physics Data Booklet

$\vec{F} = \frac{\Delta\vec{p}}{\Delta t}$ $\vec{F} = m\vec{a} = m\frac{\Delta\vec{v}}{\Delta t} = m\frac{\vec{v}_f - \vec{v}_i}{\Delta t} = \frac{m\vec{v}_f - m\vec{v}_i}{\Delta t} = \frac{\vec{p}_f - \vec{p}_i}{\Delta t}$

$KE = \frac{p^2}{2m}$

$\vec{I}mpulse = \vec{F}\Delta t = \Delta\vec{p}$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions.

1. Use Newton's third law of motion to complete the next sentence: Man throws rock forward.

2. What is the meaning and equation for *impulse* $\vec{J}$? Do not confuse impulse $\vec{J}$ with current I!
   http://hyperphysics.phy-astr.gsu.edu/hbase/impulse.html#c1

3. What is the meaning, symbol, equation, and fundamental units for *momentum* $\vec{p}$? Momentum is also called "*inertia in motion*." Why? Do not confuse momentum $\vec{p}$ with pressure P or power P or density ρ!
   http://hyperphysics.phy-astr.gsu.edu/hbase/mom.html#mom

4. Why are the front of cars built so weak? Why are cars so easy to damage during an accident?
   https://www.youtube.com/watch?v=v9ML4GA47Rg

5. Why do athletes have their elbows bent when catching a ball? Why do athletes have their knees bent when coming down after jumping?

6. What common mistake do people make when firing/shooting a gun?
   https://www.youtube.com/watch?v=bYWzMDVgweg

7. What does the law of *conservation of momentum* tell us? What is the equation for the law of conservation of momentum?
   http://hyperphysics.phy-astr.gsu.edu/hbase/conser.html#conmom

8. What is an *elastic collision*? Is momentum conserved? Is kinetic energy conserved? Is total energy conserved?
   http://hyperphysics.phy-astr.gsu.edu/hbase/elacol.html#c4

9. What is an *inelastic collision*? Is momentum conserved? Is kinetic energy conserved? Is total energy conserved?
   http://hyperphysics.phy-astr.gsu.edu/hbase/inecol.html#c1

10. What is a *perfectly inelastic collision*? Is momentum conserved? Is kinetic energy conserved? Is total energy conserved?

11. What does the area under a *force vs. time graph* tell us?
    http://physicsnet.co.uk/a-level-physics-as-a2/further-mechanics/momentum-concepts/

12. What does the slope of a line on a *force vs. time graph* tell us?

13. A 2 kg block is moving east with a speed of 5 m/s. It hits a wall and rebounds to the west at a speed of 4 m/s. What is the magnitude and direction of the change in momentum of the block?

14. A 2 kg block is moving east on a frictionless surface with a speed of 5 m/s. It then moves on a rough surface for three seconds. Finally it continues to move east on a frictionless surface with a new speed of 1 m/s. What is the force of friction of the rough surface?

How to solve problems related to the *law of conservation of momentum*

1. Make two drawings: a "before the collision/explosion" drawing and an "after the collision/explosion" drawing.
2. Use the *law of conservation of momentum*: p_i for the initial drawing and p_f for the final drawing. Set $\vec{p}_i = \vec{p}_f$.
3. Solve for the unknowns.

Part 2: Answer the following questions

Round all your answers to two decimal points. Show all work!

1. A 3 kg block is moving west at 4 m/s on a frictionless horizontal surface. A 5 kg block is moving east at 6 m/s on the same surface. Both of them collide and stick together.
   a. What is the final speed and direction of the block?
   b. Is momentum conserved?
   c. What is the initial total kinetic energy?
   d. What is the final total kinetic energy?
   e. Is kinetic energy conserved?
   f. Is this an elastic or inelastic collision?
   g. Is total energy conserved?

2. A 7 kg block is moving north at 8 m/s on a frictionless horizontal surface. A 9 kg block is moving south at 10 m/s on the same surface. They collide. The 7 kg block is now moving south at 4 m/s.
   a. What is the final speed and direction of the 9 kg block?
   b. Is momentum conserved?
   c. What is the initial total kinetic energy?
   d. What is the final total kinetic energy?
   e. Is kinetic energy conserved?
   f. Is this an elastic or inelastic collision?
   g. Is total energy conserved?

3. A 12 kg block is initially at rest on a frictionless horizontal surface. It then explodes into three pieces. A 3 kg block moves west at 4 m/s. A 5 kg block moves east at 6 m/s.
   a. What is the final speed and direction of the 4 kg block?
   b. Is momentum conserved?
   c. What is the initial total kinetic energy?
   d. What is the final total kinetic energy?
   e. Is kinetic energy conserved?
   f. Is total energy conserved?

4. A 12 kg block is moving east at 13 m/s on a frictionless horizontal surface. It then explodes into three pieces. A 4 kg block moves west at 5 m/s. A 6 kg block moves east at 7 m/s.
   a. What is the final speed and direction of the 2 kg block?
   b. Is momentum conserved?
   c. What is the initial total kinetic energy?
   d. What is the final total kinetic energy?
   e. Is kinetic energy conserved?
   f. Is total energy conserved?

5. A 4 kg block is moving east at 5 m/s on a frictionless horizontal surface. It collides with a 6 kg block initially at rest. The 4 kg block then moves northeast at 3 m/s at an angle of 30° above the horizontal.

   a. **Use a pencil!** Draw an initial and final figure.

Initial	Final

   b. Use the law of conservation of momentum for each axis to determine the final speed (in m/s) and direction (in degrees) of the 6 kg block.
   c. Is momentum conserved?
   d. What is the initial total kinetic energy?
   e. What is the final total kinetic energy?
   f. Is kinetic energy conserved?
   g. Is this an elastic or inelastic collision?
   h. Is total energy conserved?

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3.1 Thermal Concepts

http://hyperphysics.phy-astr.gsu.edu/hbase/heacon.html#heacon

Understandings

- Molecular theory of solids, liquids, and gases
- Temperature and absolute temperature
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/temper.html#c1
- Internal energy
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/inteng.html#c2
- Specific heat capacity
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/spht.html#c1
- Phase change
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/phase.html#c1
- Specific latent heat

Equations

$Q = mc\Delta T$

$Q = mL$

If you are interested in learning more about thermal physics then please read the book *Concepts in Thermal Physics* by Stephen J. Blundell and Katherine M. Blundell.

Visiting the coldest town in the world - Chilling Out | 60 Minutes Australia
60 Minutes Australia
https://www.youtube.com/watch?v=l1noUh2NrLI

The hottest place on Earth | 60 Minutes Australia
60 Minutes Australia
https://www.youtube.com/watch?v=bdeOZ6rJ36Q

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. Define *solid*. What are its characteristics?
   https://openstax.org/books/chemistry-2e/pages/1-2-phases-and-classification-of-matter

2. Define *fluid.*
   https://openstax.org/books/college-physics-ap-courses/pages/11-1-what-is-a-fluid

3. Define *liquid*. What are its characteristics?

4. Define *gas*. What are its characteristics?

5. Define *diffusion.*
   https://openstax.org/books/college-physics-ap-courses/pages/12-7-molecular-transport-phenomena-diffusion-osmosis-and-related-processes

6. Which state of matter has the most potential energy: a solid, a liquid, or a gas?

7. Define *temperature.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/temper.html
   https://www.nist.gov/pml/weights-and-measures/si-units-temperature

8. Define *degrees Fahrenheit*. What is the melting point and the boiling point of water in Fahrenheit?
   https://www.nist.gov/pml/weights-and-measures/si-units-temperature
   https://www.youtube.com/watch?v=Xy2qVIhTtG8

9. Define *degrees Celsius*. What is the melting point and the boiling point of water in degrees Celsius?

10. Define *Kelvin*. What is the melting point and the boiling point of water in Kelvin?

11. Define *absolute zero.*
    https://www.nist.gov/pml/weights-and-measures/si-units-temperature

12. Which has greater kinetic energy: *0 ℃* ice or *0 ℃* water? Which has greater potential energy?

13. Define *thermal equilibrium.*
    http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/thereq.html#c2

14. Define *heat.*
    http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heat.html

15. Define *internal energy.*
    http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/inteng.html

16. What does the equation $Q = mc\Delta T$ tell us? Define and give the units of each variable.
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/spht.html

17. Define *melting*. Does an object gain potential energy or lose potential energy when it melts? What about kinetic energy?
https://study.com/academy/lesson/phase-change-evaporation-condensation-freezing-melting.html

18. Define *freezing*. Does an object gain potential energy or lose potential energy when it freezes? What about kinetic energy?

19. Define *vaporization/boiling*. Does an object gain potential energy or lose potential energy when it vaporizes/boils? What about kinetic energy?

20. Define *condensation*. Does an object gain potential energy or lose potential energy when it condenses? What about kinetic energy?

21. What does the equation $Q = mL_f$ tell us? Define and give the units of each variable.
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/phase2.html

22. What does the equation $Q = mL_v$ tell us? Define and give the units of each variable.

Part 2: Answer the following questions

1. Moses has 500 grams of gold.
   a. What is the specific heat capacity of gold in $\frac{J}{kg\times℃}$?
   http://hyperphysics.phy-astr.gsu.edu/hbase/Tables/sphtt.html
   b. How much energy will it take to increase the temperature of solid gold by 50°C?
   c. How much energy will be lost by solid gold if its temperature decreases by 50°C?

2. How much energy will be needed to increase the temperature of 0.8 kg of solid ice from minus 30°C to steam at plus 140°C? Draw a temperature vs. energy graph of this process.
   http://hyperphysics.phy-astr.gsu.edu/hbase/Tables/phase.html#c1

3. Aaron drops a 6 kg gold block with a temperature of 20°C into a tub with 2 kg of liquid water at 90°C. What will be the final temperature of the system?
   http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/coocof2.html#c1

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3.2 Modeling a Gas

http://hyperphysics.phy-astr.gsu.edu/hbase/heacon.html#heacon

Understandings

- Pressure
- Equation of state for an ideal gas https://openstax.org/books/university-physics-volume-2/pages/2-1-molecular-model-of-an-ideal-gas
- Kinetic model of an ideal gas
- Mole, molar mass, and the Avogadro constant https://openstax.org/books/university-physics-volume-2/pages/2-1-molecular-model-of-an-ideal-gas
- Differences between real and ideal gases

Equations

$$p = \frac{F}{A}$$

$$n = \frac{N}{N_A}$$

$$pV = nRT$$

$$\bar{E}_K = \frac{3}{2}k_B T = \frac{3}{2}\frac{R}{N_A}T$$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. Define *Avogadro's constant.*
   https://www.nist.gov/si-redefinition/meet-constants

2. Define and give the units for each variable for a *mole* $n = N/N_A$.
   https://www.nist.gov/pml/weights-and-measures/si-units-amount-substance
   http://hyperphysics.phy-astr.gsu.edu/hbase/Kinetic/idegas.html

3. Define and give the units of *atomic mass unit u.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/nucuni.html

4. Define and give the units for each variable for *pressure* $p = F/A$. Is it a scalar or vector? Do not confuse pressure p with power P or momentum $\vec{p}$ or density ρ!
   http://hyperphysics.phy-astr.gsu.edu/hbase/press.html

5. Define and give the units for each variable for density $\rho = m/V$. Is it a scalar or vector? Do not confuse density ρ with power P or momentum $\vec{p}$ or pressure p!
   http://hyperphysics.phy-astr.gsu.edu/hbase/dens.html

6. State some characteristics of an *ideal gas.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/Kinetic/idgcon.html#c1
   a. high temperature, low density, and low pressure

   b.

   c.

   d.

   e.

   f.

   g.

7. Define and draw a graph showing *Boyle's Law.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/Kinetic/idgcon.html#c1

8. Define and draw a graph showing *Charles' Law.*
   https://www.thermal-engineering.org/what-is-charless-law-definition/

9. Define and draw a graph showing *Gay-Lussac's Law.*
https://www.thermal-engineering.org/what-is-guy-lussacs-law-definition/

10. Define and give the units of each variable for the *Ideal Gas Law* $PV = nRT$.
http://hyperphysics.phy-astr.gsu.edu/hbase/Kinetic/idegas.html

11. Define and give the units for each variable of the equation for *Boltzmann's constant* $k_B = \frac{R}{N_A}$.
https://www.nist.gov/si-redefinition/kelvin/kelvin-boltzmann-constant

12. Define and give the units for each variable for the equation for the internal energy of an ideal gas $\bar{E}_K = \frac{3}{2}k_B T = \frac{3}{2}\frac{R}{N_A}T$.
http://hyperphysics.phy-astr.gsu.edu/hbase/Kinetic/kintem.html

Part 2: Answer the following questions

1. What is the *average kinetic energy* and speed of O_2 at room temperature 20°C? Assume O_2 is an ideal gas.

2. What is the *molar mass* of H_2O?

3. How many *moles* are in 50 grams of H_2O?

4. How many grams are in 20 moles of H_2O?

5. What is the number of moles of an ideal gas in 80 cm^3 at room temperature of 20°C and a pressure of 10^5 Pa?

6. Three moles of an ideal gas originally occupies a volume of 120 cm^3 with a pressure of 10^5 Pa at a temperature of 23℃. What will be its new volume if its pressure is held constant and its temperature increases to 35℃?

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4.1 Oscillations

Understandings
http://hyperphysics.phy-astr.gsu.edu/hbase/shm.html#c1
https://openstax.org/books/university-physics-volume-1/pages/15-1-simple-harmonic-motion

- Simple harmonic oscillations
- Time period, frequency, amplitude, displacement, and phase difference
  http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/sound.html#c1
- Conditions for simple harmonic motion

Equations

$T = \frac{1}{f}$

If you are interested in learning more about waves then please read the book *Vibrations and Waves* by George C. King.

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Answer the following questions

1. Define *oscillation.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/sound.html#c1

2. Give three examples of oscillations.
   a.

   b.

   c.

3. Define *periodic.*
   https://openstax.org/books/college-physics/pages/16-introduction-to-oscillatory-motion-and-waves

4. Define *period.* Units?

5. Define *amplitude.* Units?

6. Define *frequency*. Units?

7. What is the mathematical relationship between the *frequency* and *period* of a wave?
   https://openstax.org/books/college-physics-ap-courses/pages/16-2-period-and-frequency-in-oscillations

8. Section 2.1 Review: The slope of a displacement vs. time graph tells us the _____ of an object while the slope of a velocity vs. time graph tells us the _____ of an object.

9. Section 2.2 Review: Define *equilibrium.*
   https://openstax.org/books/college-physics/pages/16-introduction-to-oscillatory-motion-and-waves

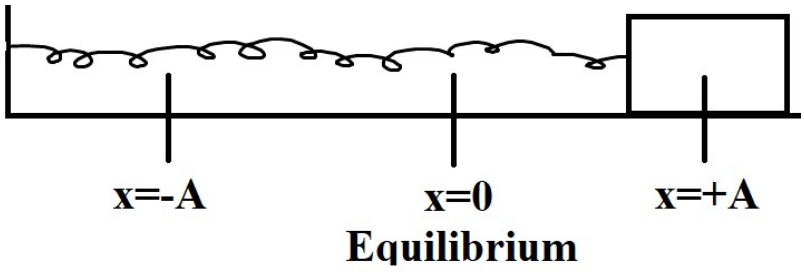
10. Give the name, define, and give the units of each variable from Hooke's Law $\vec{F} = -k \times \Delta\vec{x}$.
    https://openstax.org/books/college-physics/pages/16-introduction-to-oscillatory-motion-and-waves
    $\vec{F}$:

    k:

    $\Delta\vec{x}$:

    The minus sign:

11. A mass lying on a smooth horizontal surface is attached to a spring and is stretched from its equilibrium position. It is then released. Label the forces on the mass.



12. **Use a pencil and ruler!** Draw and label an acceleration vs. displacement graph for simple harmonic motion.

$$\vec{F} = m\vec{a} = -k \times \Delta\vec{x}$$

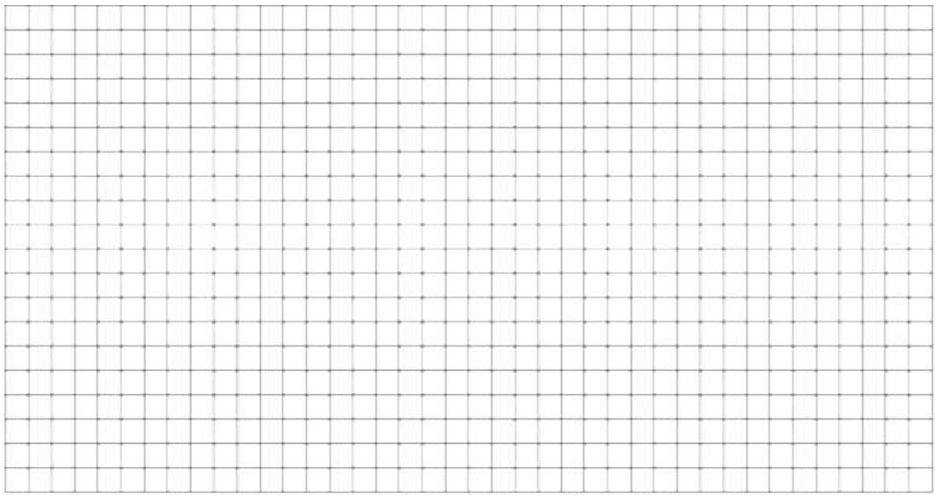
13. What are the main characteristics of simple harmonic motion?
https://openstax.org/books/college-physics-ap-courses/pages/16-3-simple-harmonic-motion-a-special-periodic-motion

a.

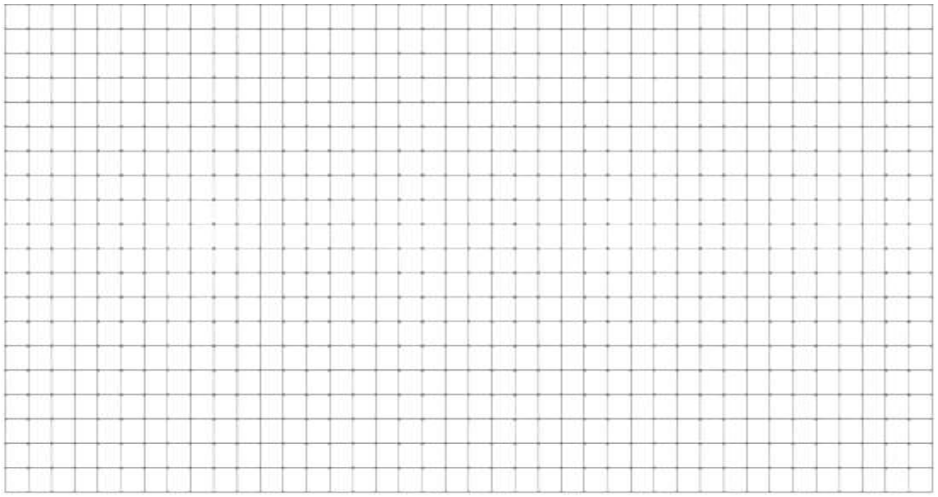
b.

c.

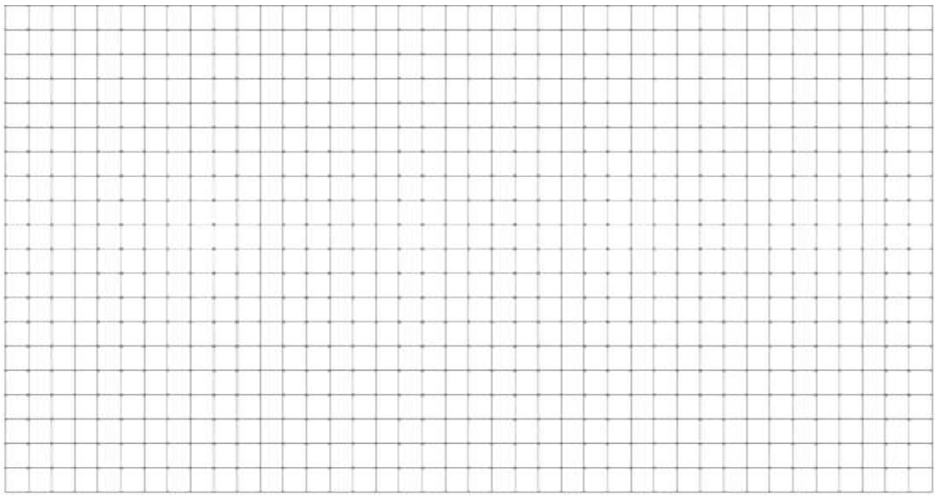
14. **Use a pencil and ruler!** Draw two waves which are in phase.
https://www.easyelimu.com/high-school-notes/physics/form-2/item/750-waves-1



15. **Use a pencil and ruler!** Draw two waves which are out of phase by 180°.
https://www.allaboutcircuits.com/textbook/alternating-current/chpt-1/ac-phase/



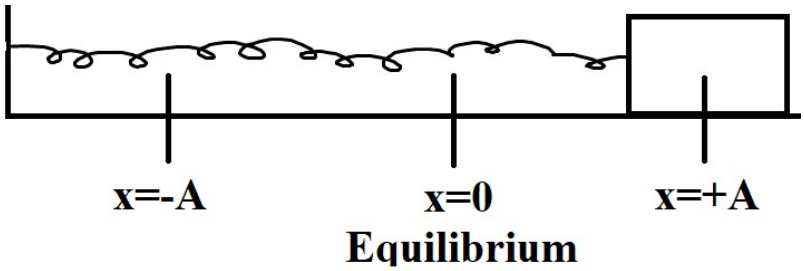
16. **Use a pencil and ruler!** Draw two waves which are out of phase by 90°.



17. **Use a pencil!** The total energy of a simple harmonic oscillator is given by the equation $E = KE + PE = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = constant$. In the figure below label the locations of

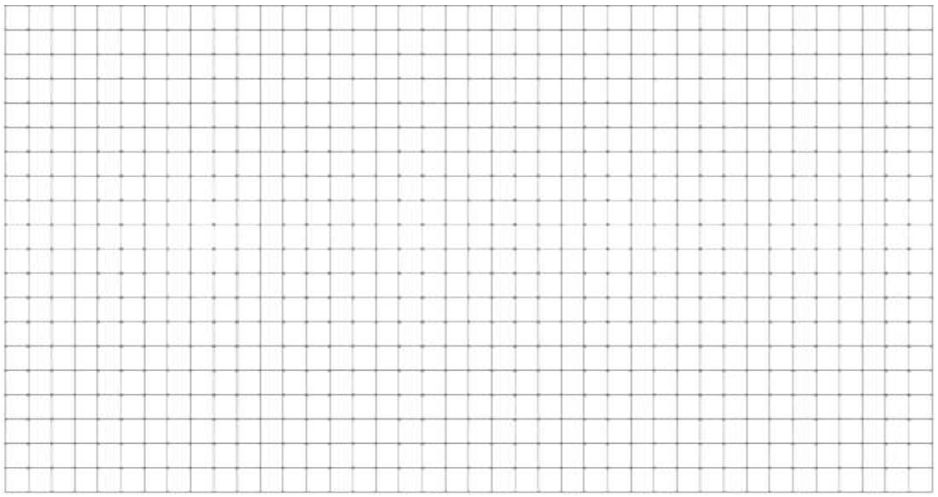
KE_{max}	$KE_{min} = 0\,J$	PE_{max}	$PE_{min} = 0\,J$
a_{max}	$a_{min} = 0\frac{m}{s^2}$	v_{max}	$v_{min} = 0\frac{m}{s}$

https://openstax.org/books/university-physics-volume-1/pages/15-2-energy-in-simple-harmonic-motion



18. What is the mathematical relationship between the energy and amplitude of an object in simple harmonic motion?

19. **Use a pencil and ruler!** On the graph below draw an *energy vs. displacement* graph for a mass on a spring with three curves: a potential energy vs. displacement curve, a kinetic energy vs. displacement curve, and a total energy vs. displacement curve.



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4.2 Traveling Waves

Understandings

- Traveling waves
  https://openstax.org/books/university-physics-volume-1/pages/16-1-traveling-waves
- Wavelength, frequency, period, and wave speed
  http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/sound.html#c1
- Transverse and longitudinal waves
  http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/tralon.html#c1
- The nature of electromagnetic waves
  http://hyperphysics.phy-astr.gsu.edu/hbase/emwav.html#c1
  http://hyperphysics.phy-astr.gsu.edu/hbase/ems1.html#c1
- The nature of sound waves
  http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

Equations

$v = \lambda f$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Answer the following questions

1. What is a *wave*? What do waves transfer? What do waves not transfer?
   https://openstax.org/books/college-physics/pages/16-9-waves
   https://www.sciencelearn.org.nz/resources/120-waves-as-energy-transfer

2. How are all waves created?
   https://courses.lumenlearning.com/boundless-physics/chapter/waves/

3. Define *medium.*
   https://www.physicsclassroom.com/class/waves/Lesson-1/What-is-a-Wave

4. Define *vacuum.*
   www.dictionary.com
   http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/vacfla.html

5. Define *mechanical wave.* Give an example.
   https://www.online-sciences.com/physics/properties-of-mechanical-waves-and-electromagnetic-waves/

6. Define *electromagnetic waves*. Give some examples.
   https://physics.info/em-waves/

7. Define *longitudinal wave*. Give an example.
   http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/tralon.html

8. Define *compression.*
   https://www.siyavula.com/read/science/grade-10/longitudinal-waves/09-longitudinal-waves-02

9. Define *rarefaction.* Do not confuse *rarefaction* with *refraction*!

10. **Use a pencil and ruler!** Draw a *longitudinal wave*. Label the *compression* and *rarefaction*.
    https://physics818.wordpress.com/2015/03/26/waves/

11. Define *transverse wave.* Give an example.
    http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/tralon.html

12. Define *crest.*
    https://www.siyavula.com/read/science/grade-10/transverse-waves/08-transverse-waves-03

13. Define *trough.*

14. **Use a pencil and ruler!** Draw a *transverse wave*. Label the *crest* and *trough*.
https://physics818.wordpress.com/2015/03/26/waves/

15. Define *wavelength* λ. Units?

16. Define *period* T. Units?
https://www.physicsclassroom.com/class/waves/Lesson-2/Frequency-and-Period-of-a-Wave

17. Define *frequency* f. Units?
https://www.physicsclassroom.com/class/waves/Lesson-2/Frequency-and-Period-of-a-Wave

18. State the equation which relates the *speed*, *wavelength*, and *frequency* of a wave.

19. What information can we obtain from a *displacement vs. distance* graph?
http://www.excelatphysics.com/graphs-for-sound-wave.html

20. What information can we obtain from a *displacement vs. time* graph?
http://www.excelatphysics.com/graphs-for-sound-wave.html

21. Imagine a boat which is in the middle of the ocean. A water wave passes under it. What happens to the boat? Does it travel vertically (up and down)? Does it travel horizontally (left and right)? Both? Neither?

22. What is the speed of sound in a vacuum? In air? In a metal?
http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/souspe.html#c1

23. What is the speed of an electromagnetic wave in a vacuum? In air? In a metal?
http://hyperphysics.phy-astr.gsu.edu/hbase/Relativ/ltrans.html#c3

24. For sound waves pitch is directly proportional to _____ and loudness is directly proportional to _____.

25. List the seven electromagnetic waves in order of decreasing wavelength λ, increasing frequency f, and increasing energy $E = hf$.
https://www.miniphysics.com/electromagnetic-spectrum_25.html
http://hyperphysics.phy-astr.gsu.edu/hbase/mod3.html#c6
a.

b.

c.

d.

e.

f.

g.

26. ROY G BIV
https://www.youtube.com/watch?v=wfIgC_PRTVc

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4.3 Wave Characteristics

Understandings:

- Wavefronts and rays
- Amplitude and intensity
- Superposition
- Polarization
  https://openstax.org/books/university-physics-volume-3/pages/1-7-polarization

Equations

$I \propto A^2$

$I \propto \frac{1}{x^2}$

$I = I_0(\cos\theta)^2$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. Define *wavefront.*
   https://www.youtube.com/watch?v=BGLbuj54Xck

2. Define *ray.*
   https://www.youtube.com/watch?v=BGLbuj54Xck

3. **Use a pencil and ruler!** Draw 3 wavefronts and 8 rays after a small rock falls vertically and hits water.
   https://kaiserscience.wordpress.com/category/optics/page/2/

4. **Use a pencil and ruler!** Draw 2 wavefronts and 8 rays after a long thin rod falls horizontally and hits water.

5. Define *intensity*. Units?
   https://courses.lumenlearning.com/physics/chapter/16-11-energy-in-waves-intensity/

6. What is the mathematical relationship between the *intensity* and *amplitude* of a wave? What about the *energy* and *amplitude* of a wave?
https://physics.info/intensity/

7. What is the mathematical relationship between the *intensity* and *distance* from a wave source?
https://www.physicskey.com/37/wave-energy-power-and-intensity

8. Define *superposition.*
https://www.acs.psu.edu/drussell/Demos/superposition/superposition.html
http://hyperphysics.phy-astr.gsu.edu/hbase/Waves/wpack.html

9. **Use a pencil and ruler!** Draw a before, during, and after image of two pulses on a rope traveling in opposite directions which go through **constructive interference**.
https://www.acs.psu.edu/drussell/Demos/superposition/superposition.html

10. **Use a pencil and ruler!** Draw a before, during, and after image of two pulses on a rope traveling in opposite directions which go through **destructive interference**.

11. **Use a pencil and ruler!** Draw a before and after image of a single pulse wave on a string striking and being reflected from a vertical pole with a **fixed end**.
https://www.acs.psu.edu/drussell/demos/reflect/reflect.html

12. **Use a pencil and ruler!** Draw a before and after image of a single pulse wave on a string striking and being reflected from a vertical pole with a **free/loose end**.

13. Define *unpolarized light.*
https://www.physicsclassroom.com/class/light/Lesson-1/Polarization
https://openstax.org/books/university-physics-volume-3/pages/1-7-polarization

14. Define *polarized light.*
http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/polclas.html

15. Define *Malus's Law.*
http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/polcross.html

Part 2: Learning about polarization from videos

Watch the following videos and answer the following questions. Show all your work:

Physics - Optics: Polarization (1 of 5) Introduction
Michel van Biezen
https://www.youtube.com/watch?v=5pHZI7p1FIw

1. What is a *polarizer*?

2. What is the relationship between the incoming intensity of light and the outgoing intensity of light after the light goes through a polarizer? Give an equation and draw a figure.

Physics - Optics: Polarization (2 of 5) Two Polarizers
Michel van Biezen
https://www.youtube.com/watch?v=bT5ZW3RX41Y

3. There are two polarizers. The first polarizer is vertically polarized. The second polarizer is placed behind the first polarizer and is shifted 30 degrees from the first polarizer. Draw a figure of the setup and find the intensity of the light after it goes through both polarizers.

4. What would be the outgoing intensity if two polarizers are placed next to each other and are shifted 90 degrees from each other? Draw a figure of the setup and find the intensity of the light after it goes through both polarizers.

Physics - Optics: Polarization (3 of 5) Three Polarizers
Michel van Biezen
https://www.youtube.com/watch?v=r1sZY826Qys

5. There are three polarizers. The first polarizer is vertically polarized. The second polarizer is placed behind the first polarizer and is shifted 45 degrees from the first polarizer. The third polarizer is placed behind the second polarizer and is shifted 45 degrees from the second polarizer. Draw a figure of the setup and find the intensity of the light after it goes through all three polarizers. Show all your work.

AP Physics 2: Light 11: Polarization Problem
Yau-Jong Twu
https://www.youtube.com/watch?v=TEdlObaQNMw

6. An unpolarized light passes through two polarizer sheets. If the intensity of the transmitted light is 20% that of the original light, what is the angle between the transmission axes of the two polarizer sheets? Draw a figure and show all your work.

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4.4 Wave Behavior

Understandings

- Reflection and refraction
  http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/Fermat.html#c1
  http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/refr.html#c1
  https://openstax.org/books/university-physics-volume-3/pages/1-2-the-law-of-reflection
  https://openstax.org/books/university-physics-volume-3/pages/1-3-refraction
- Snell's law, critical angle, and total internal reflection
  https://openstax.org/books/university-physics-volume-3/pages/1-4-total-internal-reflection
- Diffraction through a single-slit and around objects
  http://alternativephysics.org/book/Diffraction.htm
- Interference patterns
- Double-slit interference
  https://openstax.org/books/university-physics-volume-3/pages/4-3-double-slit-diffraction#17252
- Path difference
  https://openstax.org/books/university-physics-volume-3/pages/3-2-mathematics-of-interference

Equations

$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$$

$$s = \frac{\lambda D}{d}$$

$$constructive\ interference\ path\ difference = n\lambda$$

$$destructive\ interference\ path\ difference = (n + \frac{1}{2})\lambda$$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. What is the *speed of light c* in a vacuum?
   http://hyperphysics.phy-astr.gsu.edu/hbase/Relativ/ltrans.html#c3

2. What is the equation, units, and meaning of *index of refraction n*? What is the range of values for the *refractive index* of an object? What is the *refractive index* for a vacuum?
   http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/refr.html#c1
   http://hyperphysics.phy-astr.gsu.edu/hbase/Tables/indrf.html#c1

3. **Use a pencil and ruler!** Define *reflection* and draw a labeled figure.
   http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/reflectcon.html

4. State the equation for the *law of reflection*.
   http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/reflectcon.html

5. **Use a pencil and ruler!** Define *refraction* and draw a labeled figure. (Do not confuse *refraction* with *rarefaction*!)
   http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/refr.html#c1

6. State the equation for refraction: *Snell's law*.
   http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/refr.html#c1

7. **Use a pencil and ruler!** Define *dispersion* and draw a labeled figure.
   http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/dispersion.html

8. **Use a pencil and ruler!** Define *total internal reflection* and *critical angle*. Draw a labeled figure.
   http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/totint.html

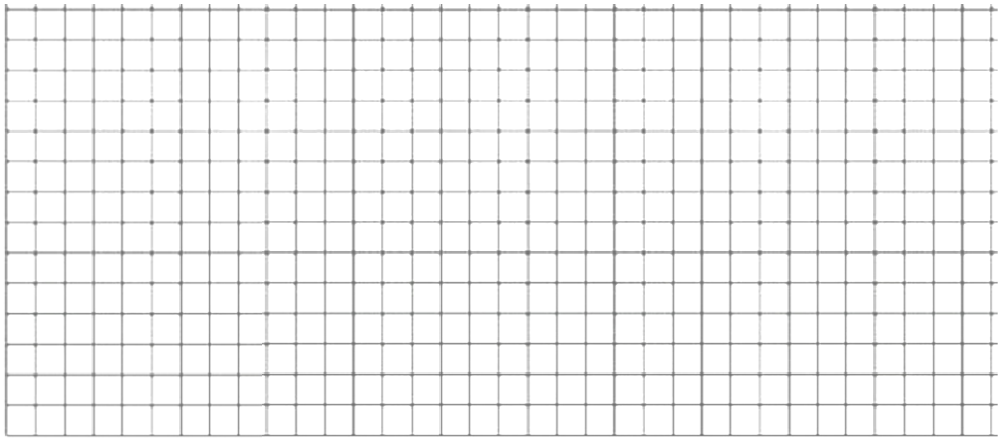
9. Define *diffraction.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/diffracon.html

10. What is the relationship between the slit width and wavelength of the wave which gives maximum diffraction?
    http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/sinslitd.html#c1

11. What is the relationship between the slit width and wavelength of the wave which gives minimum diffraction?
    http://labman.phys.utk.edu/phys222core/modules/m9/diffraction.htm

12. Light passes through a slit which is equal to the lights wavelength. What happens to the intensity of the central maximum as the slit width decreases?

13. **Use a pencil and ruler!** Draw an intensity vs. displacement graph for *single source interference*.
http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/sinslit.html#c1



14. For double source interference state the equations for
https://opentextbc.ca/physicstestbook2/chapter/youngs-double-slit-experiment/
    a. Constructive interference

    b. Destructive interference

15. The equation for double slit wave interference is $s = \frac{\lambda D}{d}$. Define the following variables:
http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/slits.html#c1

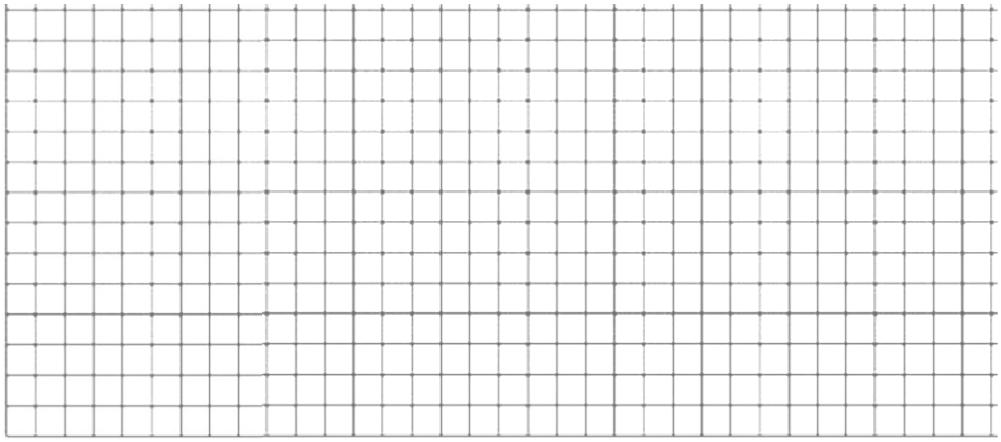
a. s

b. λ

c. D

d. d

Use a pencil and ruler! Draw a neat and detailed graph (intensity vs. displacement) for *double source interference*.



Part 2: Use a pencil and ruler! Watch and take notes on the following videos. Draw and label pictures!

Reflection
Swanson Does Science
https://www.youtube.com/watch?v=CFWFxdGWlwU&list=PLwou46-vQBXOswokM90E76P8J8Rs221Gz&index=22

Refraction
Swanson Does Science
https://www.youtube.com/watch?v=l06ntSho_6Y&list=PLwou46-vQBXOswokM90E76P8J8Rs221Gz&index=12

Refraction equation
Swanson Does Science
https://www.youtube.com/watch?v=azKUQEDrzgs&list=PLwou46-vQBXOswokM90E76P8J8Rs221Gz&index=11

Snell's law
Swanson Does Science
https://www.youtube.com/watch?v=sby0-xpqrno&list=PLwou46-vQBXOswokM90E76P8J8Rs221Gz&index=10

Combination of Snell's law and refraction equation
Swanson Does Science
https://www.youtube.com/watch?v=zUXb470BbBE&list=PLwou46-vQBXOswokM90E76P8J8Rs221Gz&index=9

Total internal reflection
Swanson Does Science
https://www.youtube.com/watch?v=edrgOowANWY&list=PLwou46-vQBXOswokM90E76P8J8Rs221Gz&index=8

Wave Diffraction
Bozeman Science
https://www.youtube.com/watch?v=1bHipDSHVG4

Diffraction Demo: Single Slit and Circular Aperture
Physics Demos
https://www.youtube.com/watch?v=uohd0TtqOaw

Interference Demo: Double Slit
Physics Demos
https://www.youtube.com/watch?v=PVyJFzx7zig

27 Inteference & Diffraction - Double slit diffraction
Cogverse Academy
https://www.youtube.com/watch?v=KeHry37evb4

Young's Double Slit Experiment
The Organic Chemistry Tutor
https://www.youtube.com/watch?v=xaAthgG0o8o

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4.5 Standing Waves

Understandings

- The nature of standing waves
- Boundary conditions
- Nodes and antinodes

https://openstax.org/books/university-physics-volume-1/pages/16-6-standing-waves-and-resonance

http://mcat-review.org/sound.php

http://hyperphysics.phy-astr.gsu.edu/hbase/Waves/standw.html#c1

Something to think about: Imagine plucking a string from a musical instrument. What is happening in terms of physics and waves?

There are some common examples of standing waves:

- Waves on a string (closed end – closed end)
- Sound waves in a pipe (open end – open end)

You need to watch animations on ***standing waves*** to perfectly understand it!

https://www.acs.psu.edu/drussell/Demos/StandingWaves/StandingWaves.html

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: List some observations which can be made from standing waves but not traveling waves

1.

2.

3.

4.

5.

6.

7.

8.

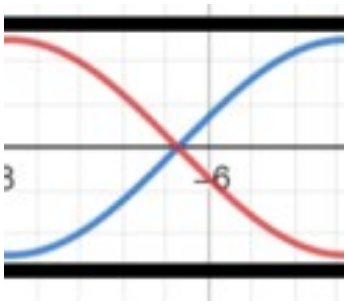
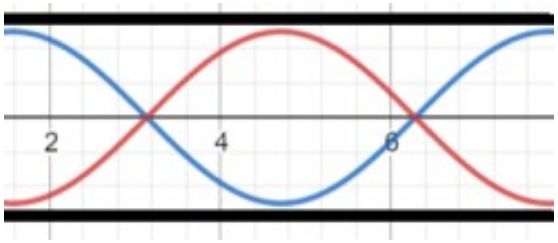
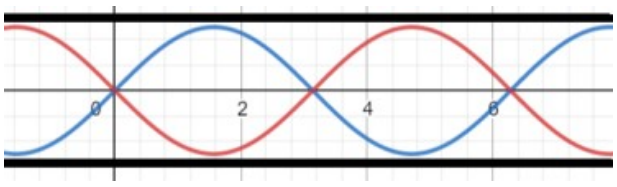
Part 2: Define the following terms

1. *Node*:
2. *Anti-node*:
3. *First harmonic*:
4. *Fundamental frequency*:

Part 3: Drawing harmonics

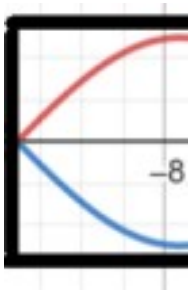
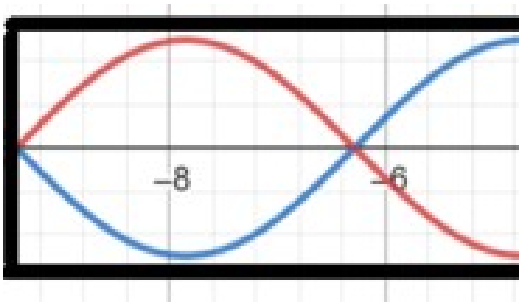
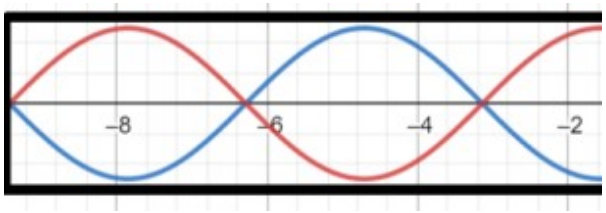
1. **Use a pencil and ruler!** Below are the first three harmonics of a tube with both ends open. The frequencies of the first three harmonics are derived for you. Draw and solve for the next three frequencies on the next page.

https://physics.info/waves-standing/

	$L = \frac{\lambda}{2}$ $\lambda = 2L$ $v = \lambda f$ $v = 2Lf$ $f = \frac{v}{2L}$
	$L = \lambda$ $\lambda = L$ $v = \lambda f$ $v = Lf$ $f = \frac{v}{L}$
	$L = \frac{3\lambda}{2}$ $\lambda = \frac{2L}{3}$ $v = \lambda f$ $v = \frac{2Lf}{3}$ $f = \frac{3v}{2L}$

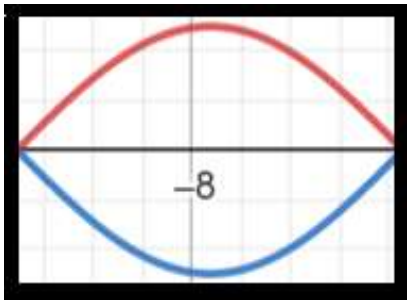
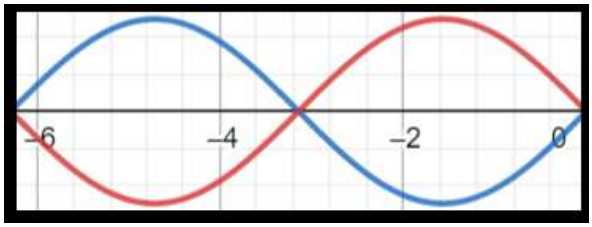
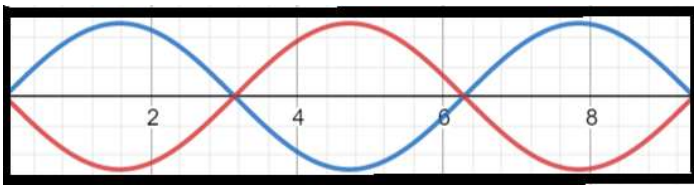
2. **Use a pencil and ruler!** Below are the first three harmonics of a tube with one end open and one end closed. The frequencies of the first three harmonics are derived for you. Draw and solve for the next three frequencies on the next page.

https://physics.info/waves-standing/

	$L = \frac{\lambda}{4}$ $\lambda = 4L$ $v = \lambda f$ $v = 4Lf$ $f = \frac{v}{4L}$
	$L = \frac{3\lambda}{4}$ $\lambda = \frac{4L}{3}$ $v = \lambda f$ $v = \frac{4Lf}{3}$ $f = \frac{3v}{4L}$
	$L = \frac{5\lambda}{4}$ $\lambda = \frac{4L}{5}$ $v = \lambda f$ $v = \frac{4Lf}{5}$ $f = \frac{5v}{4L}$

3. **Use a pencil and ruler!** Below are the first three harmonics of a tube with both ends closed. The frequencies of the first three harmonics are derived for you. Draw and solve for the next three frequencies on the next page.

https://physics.info/waves-standing/

	$L = \frac{\lambda}{2}$ $\lambda = 2L$ $v = \lambda f$ $v = 2Lf$ $f = \frac{v}{2L}$
	$L = \lambda$ $\lambda = L$ $v = \lambda f$ $v = Lf$ $f = \frac{v}{L}$
	$L = \frac{3\lambda}{2}$ $\lambda = \frac{2L}{3}$ $v = \lambda f$ $v = \frac{2Lf}{3}$ $f = \frac{3v}{2L}$

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5.1 Electric Fields

Understandings

- Charge
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elecur.html#c2
  https://openstax.org/books/university-physics-volume-2/pages/5-1-electric-charge
- Electric field
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elefie.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/5-4-electric-field
- Coulomb's law
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elefor.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/5-3-coulombs-law
- Electric current
  http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
  https://openstax.org/books/university-physics-volume-2/pages/9-introduction
- Direct current DC
  http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
- Potential difference
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elepe.html#c1
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elevol.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/7-introduction
  https://physics.info/electric-potential/

Equations

$$Current = I = \frac{\Delta q}{\Delta t} = \left[\frac{Coulombs}{seconds}\right] = [Amperes]$$

$$Coulomb's\ Law = \vec{F}_{electric} = q_1\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} = k\frac{q_1 q_2}{r^2}$$

$$Electric\ Field = \vec{E} = \frac{\vec{F}}{q_1} = \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r^2} = k\frac{q_2}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_0}$$

$$Work\ done\ in\ moving\ a\ charge = qV$$

$$I = nAvq$$

If you are interested in learning more about electricity and magnetism then please read the book *Electricity and Magnetism* by Edward M. Purcell and David J. Morin.

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. Define *static* and *dynamic*.
   www.dictionary.com

2. What is *charge q*? Units?
   http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elecur.html#c2

3. What is the difference between an *electrical conductor* and an *electrical insulator*? Give two examples of each.
   http://hyperphysics.phy-astr.gsu.edu/hbase/electric/conins.html#c1

4. State the mass, in *kg*, of each particle:
   http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/proton.html#c3
   a. Neutron

   b. Proton

   c. Electron

5. State the charge, in *C*, of each particle:
   http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elecur.html#c2
   a. Neutron

   b. Proton

   c. Electron

6. There is a metal sphere which has a net positive charge.
   a. Is there any negative charge in it?

   b. Where does the extra positive charge go?

7. Define *electric current I* and state its equation and units. Do not confuse *current I* with *impulse* $\vec{J}$!
   http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elecur.html#c1

8. What is the relationship in magnitude and direction between *electron flow* and *current* in a conductor?

9. Define *drift velocity.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/electric/miccur.html

10. Define and give the units of each variable in the equation $I = nAvq$.
    http://hyperphysics.phy-astr.gsu.edu/hbase/electric/miccur.html

11. Is lightning considered *static electricity* or *current*? Why?

12. Which is faster: the speed of thunder or the speed of lightning? Why?

13. Define and give the units of each variable in *Coulomb's Law* $\vec{F}_{electric} = k\frac{q_1 q_2}{r^2}$. What is the minimum number of objects required to use *Coulomb's law*?
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elefor.html#c1

14. Define *electric field strength* $\vec{E} = \frac{\vec{F}}{q} = k\frac{q_1}{r^2}$. What is the minimum number of objects required to use the equation for *electric field strength*?
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elefie.html#c1
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/efiecon.html#c1

15. Define *electric potential difference*. Scalar or vector? Units?
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elepe.html#c3
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elevol.html#c1
https://physics.info/electric-potential/

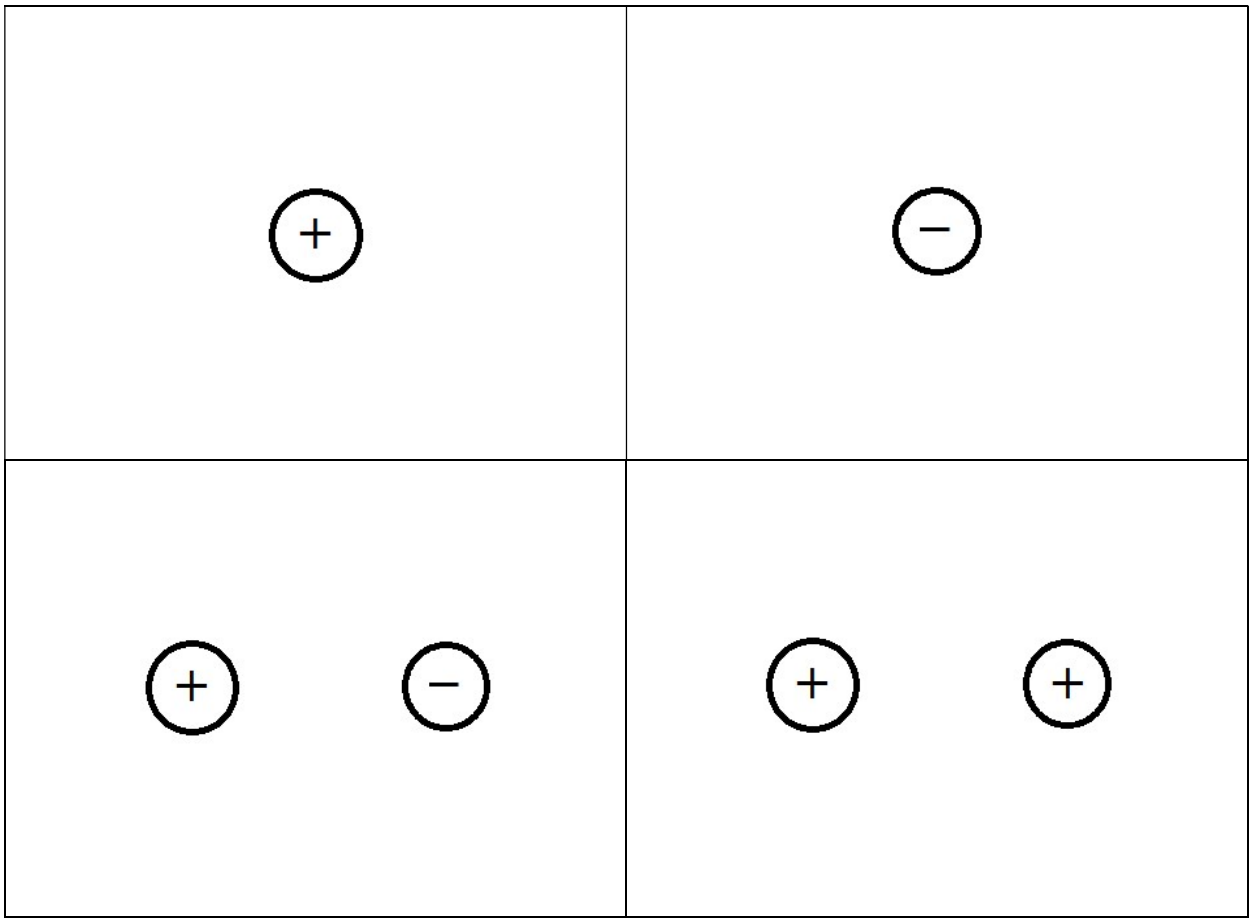
16. What are the units of *voltage*?
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elevol.html#c1

17. **Use a pencil and ruler!** The work done in moving a charge is given by the equation $W = qV$. Draw and label a diagram to describe this equation.
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elewor.html

18. Define *electron-volt*.
    http://hyperphysics.phy-astr.gsu.edu/hbase/electric/ev.html#c2

19. List some rules for electric field lines and equipotential surfaces.
    https://openstax.org/books/university-physics-volume-2/pages/5-6-electric-field-lines
    http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elefie.html
    https://www.physicsclassroom.com/class/estatics/Lesson-4/Electric-Field-Lines
    http://hyperphysics.phy-astr.gsu.edu/hbase/electric/equipot.html

20. **Use a pencil and ruler!** Draw electric field lines and equipotential surfaces for each figure.



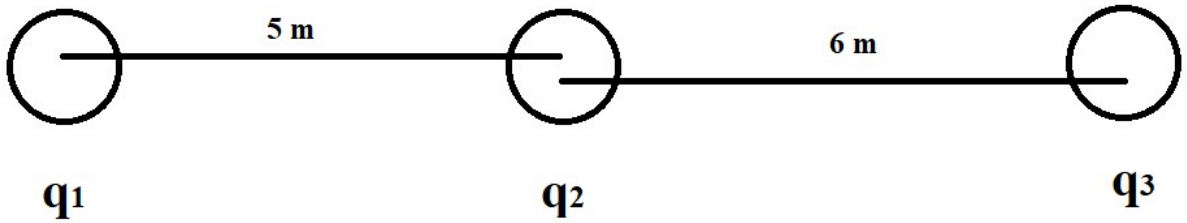
21. **Use a pencil and ruler!**
    a. Draw charged *parallel plates*.
    b. Draw (and label) four electric field lines between the parallel plates.
    c. Draw a positive charge between the plates and give the direction in which it will accelerate.
    d. Draw a negative charge between the plates and give the direction in which it will accelerate.
    e. Which variable is constant between charged parallel plates?
    f. Define each variable for the equation for parallel plates $V = Ed$ and draw (and label) six equipotential surfaces.

    http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elewor.html#c1
    https://openstax.org/books/college-physics/pages/19-2-electric-potential-in-a-uniform-electric-field
    http://structuredindependentlearning.com/lessons/Physics30/lesson-4-5

Part 2: Answer the following questions

1. Use Coulomb's law to calculate the electric force on a point charge.

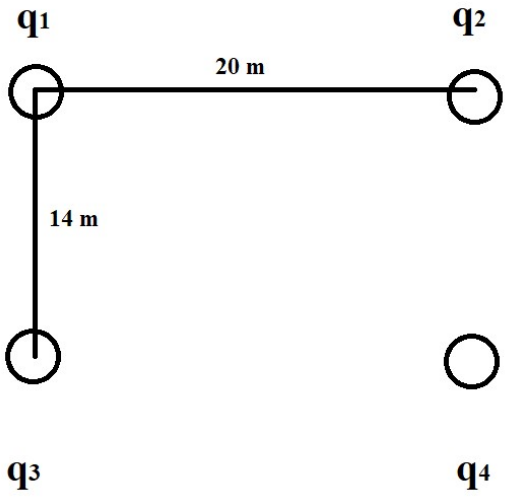
$q_1 = +2 \times 10^{-9/2}$ C	$q_2 = -3 \times 10^{-9/2}$ C	$q_3 = +4 \times 10^{-9/2}$ C



a. q_1 and q_2 are fixed. Find the force on q_3.
b. q_1 and q_3 are fixed. Find the force on q_2.
c. q_2 and q_3 are fixed. Find the force on q_1.

2. Use Coulomb's law to calculate the electric force on a point charge.

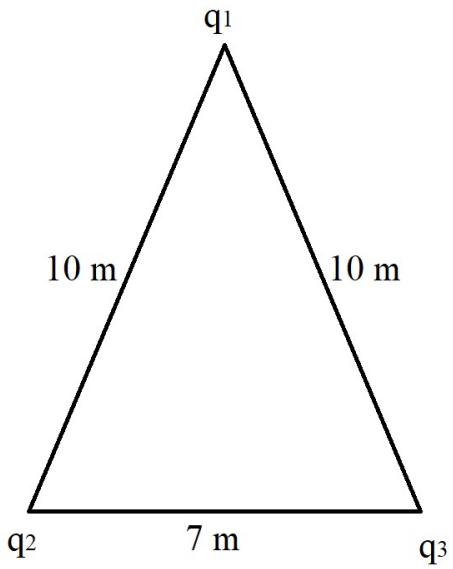
$q_1 = +2 \times 10^{-9/2}$ C	$q_2 = -3 \times 10^{-9/2}$ C
$q_3 = -4 \times 10^{-9/2}$ C	$q_4 = +5 \times 10^{-9/2}$ C



a. q_1, q_2, and q_3 are fixed. Find the force on q_4.
b. q_1, q_2, and q_4 are fixed. Find the force on q_3.
c. q_1, q_3, and q_4 are fixed. Find the force on q_2.
d. q_2, q_3, and q_4 are fixed. Find the force on q_1.

3. Use Coulomb's law to calculate the electric force on a point charge.

$q_1 = +2 \times 10^{-9/2}$ C	$q_2 = -3 \times 10^{-9/2}$ C	$q_3 = -3 \times 10^{-9/2}$ C



Point charges q_2 and q_3 are fixed. Find the force on q_1.

Name: _____

Class: _____

Due Date: _____

5.2 – Heating Effect of Electric Currents

Understandings

- Circuit diagrams
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/dcex.html#c1
- Kirchoff's circuit laws
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/ohmlaw.html#c3
  https://openstax.org/books/university-physics-volume-2/pages/10-3-kirchhoffs-rules
- Heating effect of current and its consequences
- Resistance expressed as $R = V/I$
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/ohmlaw.html#c3
  https://openstax.org/books/university-physics-volume-2/pages/9-4-ohms-law
- Ohm's law
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/ohmlaw.html#c3
- Resistivity
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/resis.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/9-3-resistivity-and-resistance
- Power dissipation
  http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elepow.html#c1

Equations

Kirchoff's circuit laws:

$\sum V = 0$ (loop)
$\sum I_{in} = \sum I_{out}$ (junction)

$R = \frac{V}{I}$

$P = IV = I^2R = \frac{V^2}{R}$

$R_{total} = R_1 + R_2 + R_3 + \cdots$ (resistors in series)

$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$ (resistors in parallel)

$\rho = \frac{RA}{L}$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. Define *inelastic*
   www.dictionary.com

2. Define resistance. Give the units of *resistance* Ω.
   https://openstax.org/books/university-physics-volume-2/pages/9-3-resistivity-and-resistance

3. What is the resistance of an ideal wire?

4. Define *resistor*. Do resistors increase or decrease the current in a circuit? Why is it necessary to have a resistor in a circuit?
   http://hyperphysics.phy-astr.gsu.edu/hbase/electric/resis.html
   http://hyperphysics.phy-astr.gsu.edu/hbase/electric/dcex3.html#c1
   https://sciencing.com/uses-resistors-5432023.html

5. What is the *resistance* of a non-ideal wire directly proportional to?

6. What is the *resistance* of a non-ideal wire inversely proportional to?

7. Define *Ohm's Law*. Draw a current vs. voltage graph of a resistor obeying Ohm's law.
https://openstax.org/books/university-physics-volume-2/pages/9-4-ohms-law

8. Define *resistivity* ρ. Do not confuse resistivity ρ with density ρ!

9. What does a *diode* do? Draw a symbol of a diode. Draw a current vs. voltage graph of a diode.
http://hyperphysics.phy-astr.gsu.edu/hbase/Solids/diod.html

10. What does a *thermistor* do? Draw a *resistance vs. temperature* graph of a thermistor.
https://openstax.org/books/university-physics-volume-2/pages/9-3-resistivity-and-resistance

11. Define *non-ohmic*.
https://openstax.org/books/university-physics-volume-2/pages/9-4-ohms-law

12. Give three versions of the equation for *electrical power*.
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elepow.html

13. Define *electromotive force emf* ε. Is *emf* a force? What are its units?
https://openstax.org/books/university-physics-volume-2/pages/10-1-electromotive-force

14. State *Kirchhoff's loop rule.*
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/ohmlaw.html

15. State *Kirchhoff's junction rule.*
https://openstax.org/books/university-physics-volume-2/pages/10-3-kirchhoffs-rules

16. Resistors in series have the same _____.
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/resis.html#c1

17. Resistors in parallel have the same _____.

18. How can we simplify many *resistors in series*?
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/resis.html

19. How can we simplify many *resistors in parallel*?

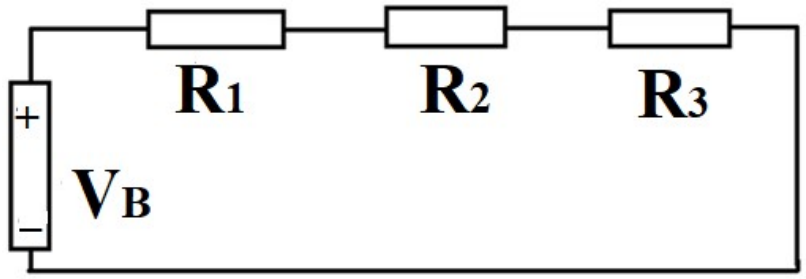
20. What does an *ammeter* do? Draw its symbol. What is a characteristic of an *ideal ammeter*? How/Where do we insert an *ammeter* in a circuit?
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/ammet.html

21. What does a *voltmeter* do? Draw its symbol. What is a characteristic of an *ideal voltmeter*? How/Where do we insert a *voltmeter* in a circuit?
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/volmet.html#c1

22. What is a *potential/voltage divider*?
https://ohmslawcalculator.com/voltage-divider-calculator

Part 2: Circuits

1.



Given:

$V_B = 10\ V$

$R_1 = 2\ \Omega$

$R_2 = 4\ \Omega$

$R_3 = 6\ \Omega$

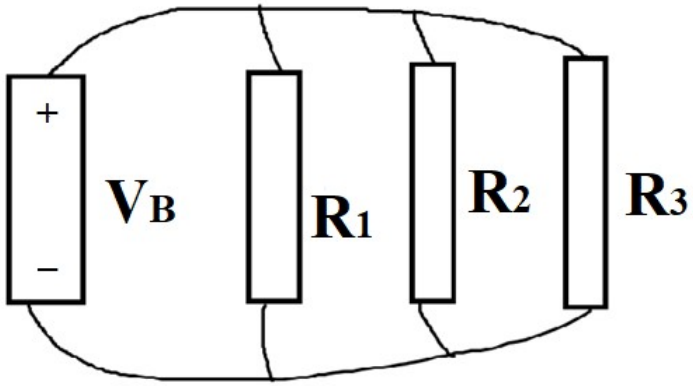
Solve for the unknowns. Reduced fractions only. Use the bottom of this page and the next page to show all your work.

$R_{equivalent} =$ $I_{battery} =$	$V_1 =$ $V_2 =$ $V_3 =$	$I_1 =$ $I_2 =$ $I_3 =$

What will happen to the current leaving the battery if the number of resistors in series increases? Will the current increase, decrease, or stay the same?

What will happen to the overall resistance of the circuit if the number of resistors in series increases? Will the overall resistance increase, decrease, or stay the same?

2.



Given:

$V_B = 10\ V$

$R_1 = 2\ \Omega$

$R_2 = 4\ \Omega$

$R_3 = 6\ \Omega$

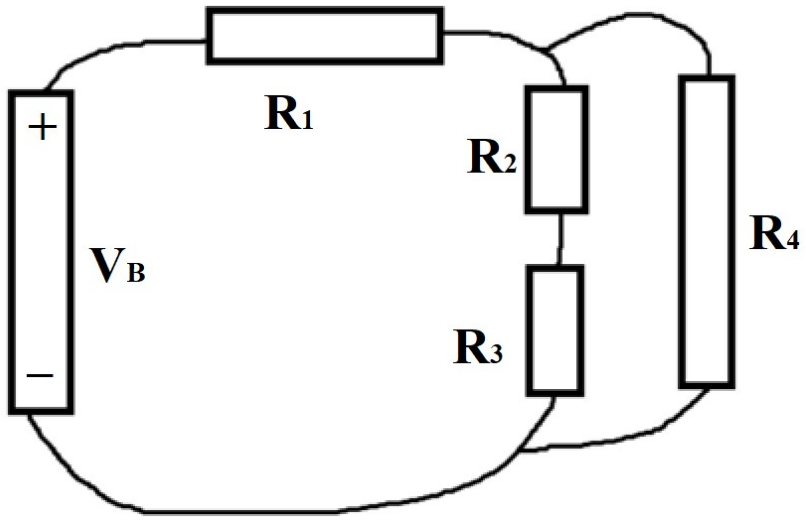
Solve for the unknowns. Reduced fractions only. Use the bottom of this page and the next page to show all your work.

$R_{equivalent} =$ $I_{battery} =$	$V_1 =$ $V_2 =$ $V_3 =$	$I_1 =$ $I_2 =$ $I_3 =$

What will happen to the current leaving the battery if the number of resistors in parallel increases? Will the current increase, decrease, or stay the same?

What will happen to the overall resistance of the circuit if the number of resistors in parallel increases? Will the overall resistance increase, decrease, or stay the same?

3.



Given:

$V_B = 10\ V$

$R_1 = 2\ \Omega$

$R_2 = 4\ \Omega$

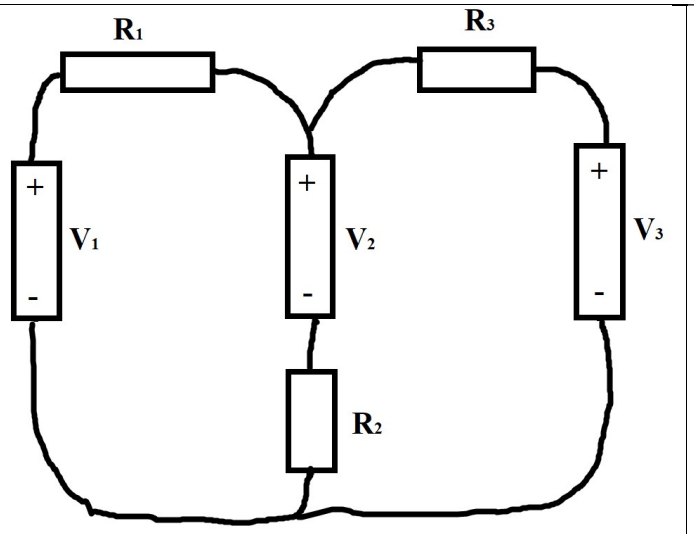
$R_3 = 6\ \Omega$

$R_4 = 8\ \Omega$

Solve for the unknowns. Reduced fractions only. Use the bottom of this page and the next page to show all your work.

	$V_1 =$	$I_1 =$
$R_{equivalent} =$	$V_2 =$	$I_2 =$
$I_{battery} =$	$V_3 =$	$I_3 =$
	$V_4 =$	$I_4 =$

4.



Given:

$V_1 = 6\ \text{V}$

$V_2 = 11\ \text{V}$

$V_3 = 17\ \text{V}$

$R_1 = 3\ \Omega$

$R_2 = 1\ \Omega$

$R_3 = 4\ \Omega$

Solve for the voltage drop and current (both magnitude and direction) through each resistor. Reduced fractions only. Use the bottom of this page and the next page to show all your work (This is actually not a good circuit. The important concept is to practice and obtain equations using Kirchoff's laws.).

$I_1 =$	$V_1 =$
$I_2 =$	$V_2 =$
$I_3 =$	$V_3 =$
$I_4 =$	$V_4 =$

Name: _____

Class: _____

Due Date: _____

5.3 Electric Cells

Understandings

- Cells
- Internal resistance
- Secondary cells
- Terminal potential difference
- Electromotive force (emf)

Equations

$\varepsilon = I(R + r)$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Answer the following questions

1. Define *electromotive force emf* ε. Is *emf* a force? What are its units? https://openstax.org/books/university-physics-volume-2/pages/10-1-electromotive-force

2. Define *internal resistance*. Units? http://hyperphysics.phy-astr.gsu.edu/hbase/electric/dcex6.html

3. Define *primary cell* and *secondary cell*. Give an example of each. https://www.differencebetween.com/difference-between-primary-and-vs-secondary-cells/

4. Define the following variables for the equation $\varepsilon = I(R + r)$. Draw an image to describe this equation.

5. A cell with internal resistance is connected to a 3 Ω resistor. Determine the internal resistance *r* of the cell if the current going through it is 2 Amps when its ε is 12 V.

6. A battery with internal resistance is connected to a variable resistor. When the resistor has a resistance of 12 Ω the current is 2 Amps. When the resistor has a resistance of 6 Ω the current is 3 Amps. Determine the emf ε and internal resistance *r* of the battery.

Name: _____

Class: _____

Due Date: _____

5.4 – Magnetic Fields $\vec{B}$

Understandings

- Magnetic fields
  http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magfie.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/11-2-magnetic-fields-and-lines
- Magnetic force
  http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magfor.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/11-4-magnetic-force-on-a-current-carrying-conductor

Equations

$$\vec{F}_{magnetic} = q\vec{v} \times \vec{B}_{external} = q\vec{v}\vec{B}_{external} \sin\theta$$

$$\vec{F}_{magnetic} = \vec{I}l \times \vec{B}_{external} = \vec{I}l\vec{B}_{external} \sin\theta$$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. Compare the following equations for force: Newton's Law of Gravitation, Coulomb's Law, and the magnetic force:

$\vec{F}_{gravity} = m_1\vec{g} = \frac{Gm_1m_2}{r^2}$ $\vec{F}_{electric} = q_1\vec{E} = \frac{kq_1q_2}{r^2}$ $\vec{F}_{magnetic} = q\vec{v} \times \vec{B}_{external}$ $= q\vec{v}\vec{B}_{external} \sin\theta$	Which force equations look similar to each other? What do they have in common? Which force equation(s) look different from each other? What do they not have in common?

2. List some differences between the electric force and the magnetic force. https://www.difference.wiki/magnetic-force-vs-electric-force/

3. What are two situations in which magnetic fields are observed?
   a. A permanent magnet
   b. A moving charge

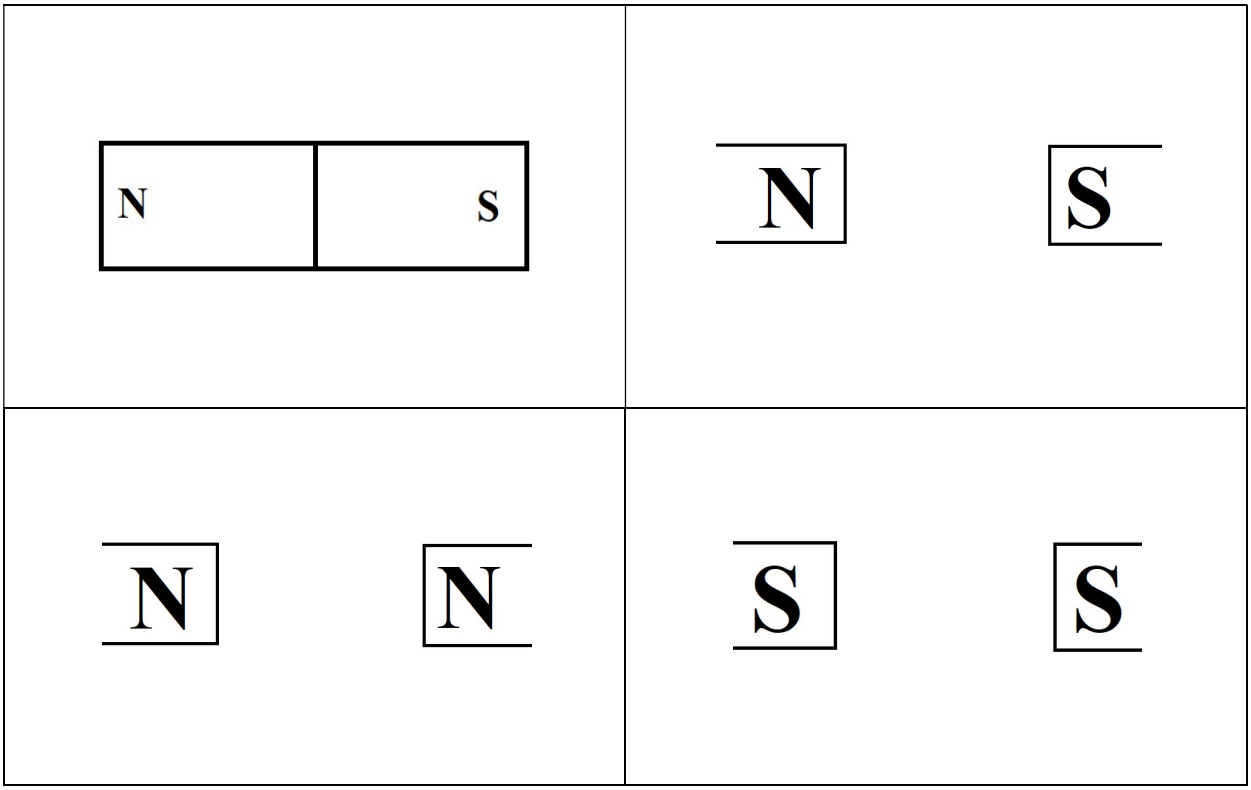
4. List some metals which have magnetic properties.
   http://hyperphysics.phy-astr.gsu.edu/hbase/Solids/ferro.html

5. Define *hard magnet*. Define *soft magnet*.
   https://www.differencebetween.com/difference-between-hard-and-vs-soft-magnetic-materials/

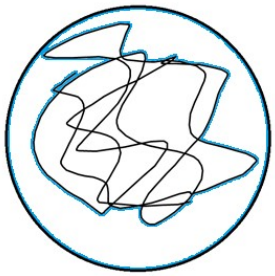
6. How can you demagnetize a magnet?
   https://sciencing.com/demagnetize-magnet-5071154.html

7. Give some rules for drawing magnetic field lines.
   https://opentextbc.ca/physicstestbook2/chapter/magnetic-fields-and-magnetic-field-lines/

8. **Use a pencil and ruler!** For each figure draw six magnetic field lines with arrows.
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/elemag.html
https://www.bbc.co.uk/bitesize/guides/zxxbkqt/revision/2



9. Draw and label the Earth's magnetic north pole (MN), magnetic south pole (MS), geographic north pole (GN), and geographic south pole (GS). Draw four magnetic field lines with arrows.
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/MagEarth.html#c1



10. What are some differences between magnetic field lines and electric field lines?
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/elemag.html

11. What is a *magnetic monopole*? Where in the universe can we find a *magnetic monopole*?

12. Look at the equation for the magnetic force:

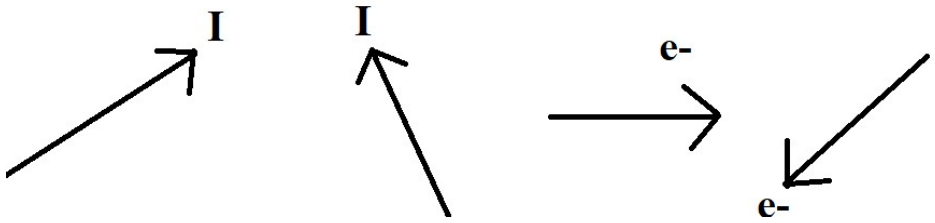
$$\vec{F}_{magnetic} = q\vec{v} \times \vec{B}_{external} = q\vec{v}\vec{B}_{external} \sin\theta$$

Do magnetic fields make moving charged objects speed up, slow down, or change direction?
https://openstax.org/books/college-physics/pages/22-5-force-on-a-moving-charge-in-a-magnetic-field-examples-and-applications

13. What are the units for the magnetic field $\vec{B}$?
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magfie.html

14. Draw the symbols for an axis going into the page and out of the page.
http://physicsed.buffalostate.edu/SeatExpts/resource/rhr/rhr.htm

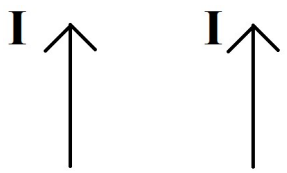
15. **Use a pencil!** Draw magnetic field lines for each current carrying wire.
https://web.iit.edu/sites/web/files/departments/academic-affairs/academic-resource-center/pdfs/Magnetic_Field.pdf
https://electricalvoice.com/right-hand-grip-cork-screw-rule/



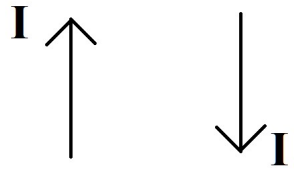
16. **Use a pencil!** Define and draw a *solenoid*. Use the right hand rule to draw magnetic field lines and the poles.
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/solenoid.html
https://www.miniphysics.com/ss-magnetic-field-due-to-current-in-a-solenoid.html

17. State three ways we can we increase the magnetic field inside a solenoid.
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/elemag.html

18. Use the equation $\vec{F}_B = I\vec{l} \times \vec{B}_{ext}$ and the right hand rule to determine if parallel wires with current moving in the same direction will *attract/repel*.



19. Use the equation $\vec{F}_B = I\vec{l} \times \vec{B}_{ext}$ and the right hand rule to determine if parallel wires with current moving in opposite directions will *attract/repel*.

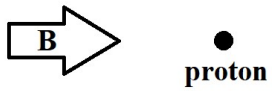


Part 2: Use your right hand to answer the following questions

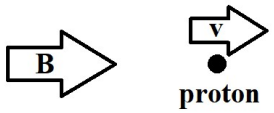
1. Use the equation $\vec{F}_B = q\vec{v} \times \vec{B}_{external}$ with the right hand rule to find the direction of the magnetic force of the charged object.

   http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magfor.html

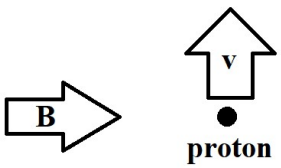
   a. A proton is at rest. A magnetic field with constant magnitude points to the right. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



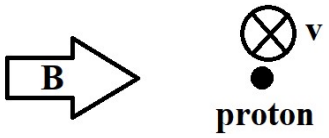
   b. A proton moves to the right with a constant speed. A magnetic field with constant magnitude points to the right. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



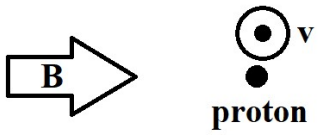
   c. A proton moves up with a constant speed v. A magnetic field with constant magnitude points to the right. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



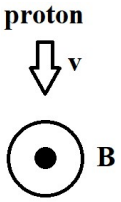
d. A proton moves into the page with a constant speed v. A magnetic field with constant magnitude points to the right. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



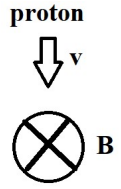
e. A proton moves out of the page with a constant speed v. A magnetic field with constant magnitude points to the right. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



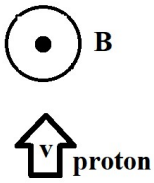
f. A proton moves down with a constant speed v. A magnetic field with constant magnitude points out of the page. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



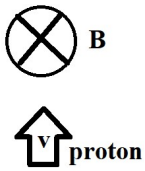
g. A proton moves down with a constant speed v. A magnetic field with constant magnitude points into the page. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



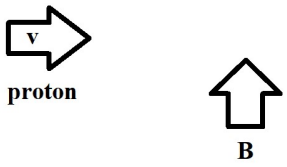
h. A proton moves up with a constant speed v. A magnetic field with constant magnitude points out of the page. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



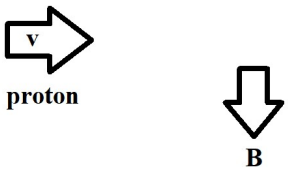
i. A proton moves up with a constant speed v. A magnetic field with constant magnitude points into the page. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



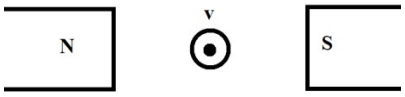
j. A proton moves to the right with a constant speed v. A magnetic field with constant magnitude points up. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



k. A proton moves to the right with a constant speed v. A magnetic field with constant magnitude points down. (What would be the direction of the magnetic force if the proton is replaced by an electron?)

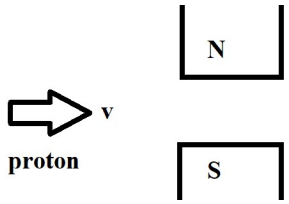


l. A proton moves out of the page with a constant speed v. (What would be the direction of the magnetic force if the proton is replaced by an electron?)

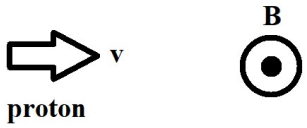


m. A proton moves into the page with a constant speed v. (What would be the direction of the magnetic force if the proton is replaced by an electron?)

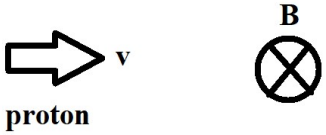
n. A proton moves to the right with a constant speed v. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



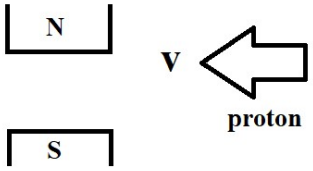
o. A proton moves to the right with a constant speed v. A magnetic field with constant magnitude points out of the page. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



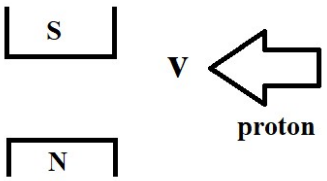
p. A proton moves to the right with a constant speed v. A magnetic field with constant magnitude points into the page. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



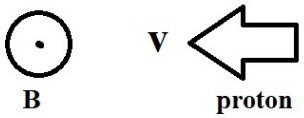
q. A proton is moving to the left with a constant speed v. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



r. A proton is moving to the left with a constant speed v. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



s. A proton is moving to the left with a constant speed v. A magnetic field with constant magnitude points out of the page. (What would be the direction of the magnetic force if the proton is replaced by an electron?)



Name: _____

Class: _____

Due Date: _____

6.1 Circular Motion

Understandings
http://hyperphysics.phy-astr.gsu.edu/hbase/circ.html#circ
https://openstax.org/books/university-physics-volume-1/pages/4-4-uniform-circular-motion

- Period, frequency, angular displacement, and angular velocity
- Centripetal force
  http://hyperphysics.phy-astr.gsu.edu/hbase/cf.html#cf
- Centripetal acceleration
  http://hyperphysics.phy-astr.gsu.edu/hbase/cf.html#cf

Common Terms and Equations

$$Circumference = 2\pi r = \pi d$$

$$\theta = angular\ distance = [radians]$$

$$\omega = angular\ speed = [radians/seconds]$$

$$\alpha = angular\ acceleration = [radians/seconds^2]$$

$$s = linear\ distance = r\theta$$

$$v = linear\ speed = r\omega$$

$$a = linear\ acceleration = r\alpha$$

$$\omega = angular\ speed = \frac{2\pi\ radians}{T} = 2\pi f$$

$$v = \frac{2\pi r}{T}$$

$$\vec{a} = \frac{v^2}{r} = \frac{\left[\frac{2\pi r}{T}\right]^2}{r} = \frac{4\pi^2 r}{T^2}$$

$$\vec{F} = m\vec{a} = m\frac{v^2}{r} = m\omega^2 r$$

If you are interested in learning about circular motion and space travel then please read the book *Project Mars* by Dr. Wernher von Braun.

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. Define *centripetal.*
   www.dictionary.com

2. Define *centrifugal.*
   www.dictionary.com

3. Are there *centripetal forces* in circular motion?
   http://hyperphysics.phy-astr.gsu.edu/hbase/cf.html#cf

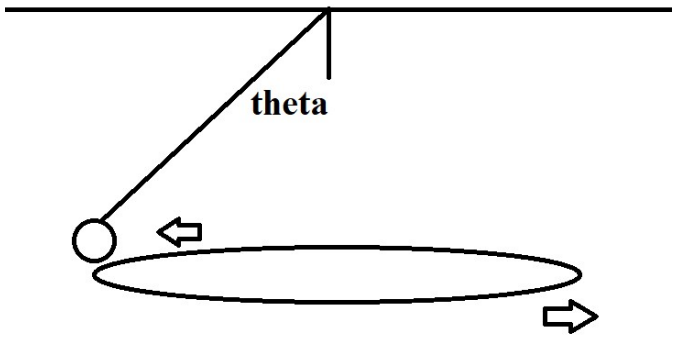
4. Are there *centrifugal forces* in circular motion?
   http://hyperphysics.phy-astr.gsu.edu/hbase/corf.html#cent

5. Imagine driving in a straight line with a constant speed of 60 km/h. You then quickly make a right turn. Do you feel a force? In which direction? Is it a centripetal force or a centrifugal force? Is it a real force? Why?

6. In circular motion how much work does the centripetal force do? Use the equation $W = \vec{F}\vec{d}\cos\theta$.

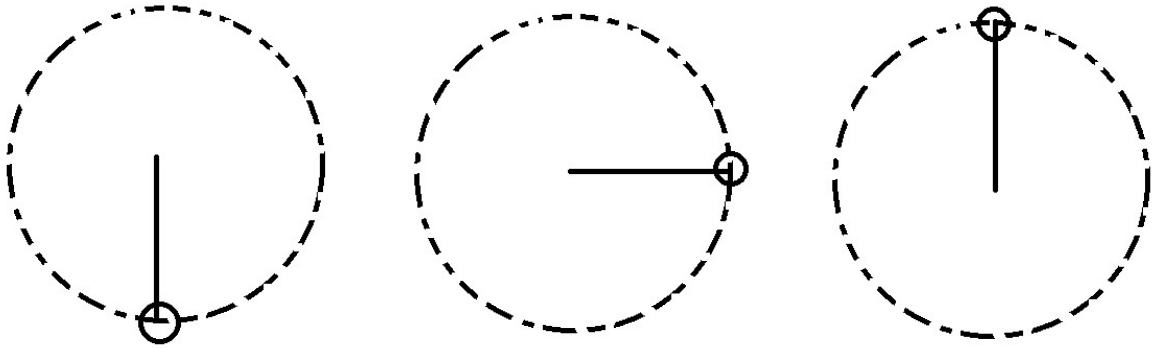
Part 2: Use a pencil and ruler!
Draw Free Body Diagrams

1. An object is attached to a string. The object moves in a horizontal circle at an angle θ from the vertical.

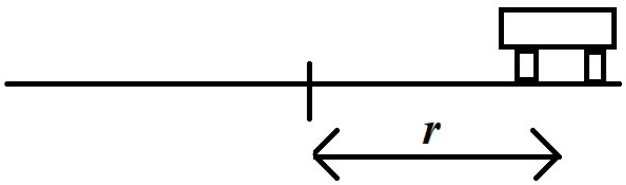


2. An object is attached to a string. The object moves in a vertical loop. Draw a free body diagram when the object is

at the bottom. halfway to the top. at the top.

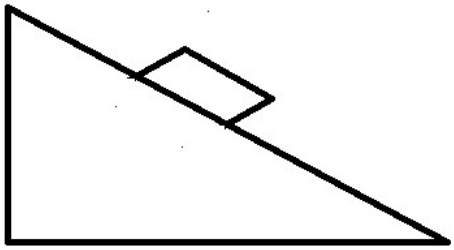


3. A car moves in a horizontal circle at a constant speed with a radius *r*.

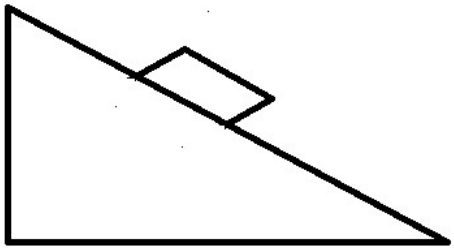


4. A car moves in a circle on a banked road with a constant radius r. There is force of friction.

a. The car is moving slow.

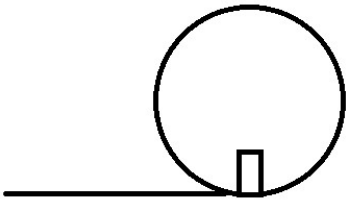


b. The car is moving fast.

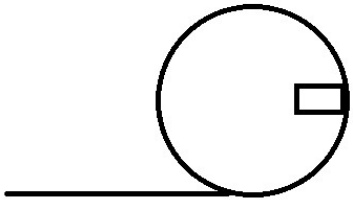


5. A cart is moving up on a vertically circular roller coaster with a radius r. There is no force of friction.

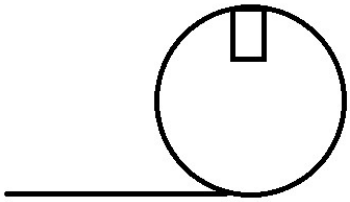
The cart is at the bottom



The cart is at a height r

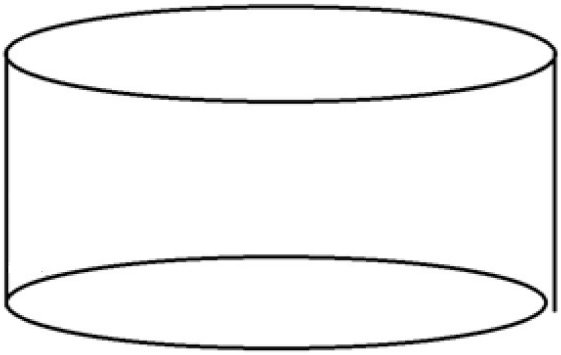


The cart is at the top



6. A fast motorcycle moves around a nonmoving cylindrical wall.

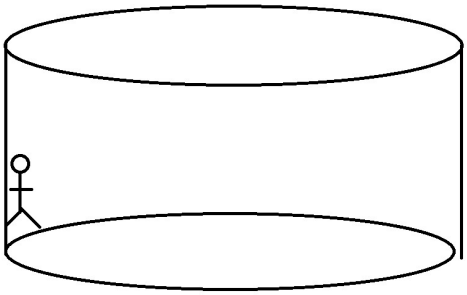
"Mauth Ka Kua" (The Well Of Death): Basic physics at its best!
Swastik Ghosh
https://www.youtube.com/watch?v=cFLNknvi7QE



7. A man is on the edge of a moving cylindrical wall.

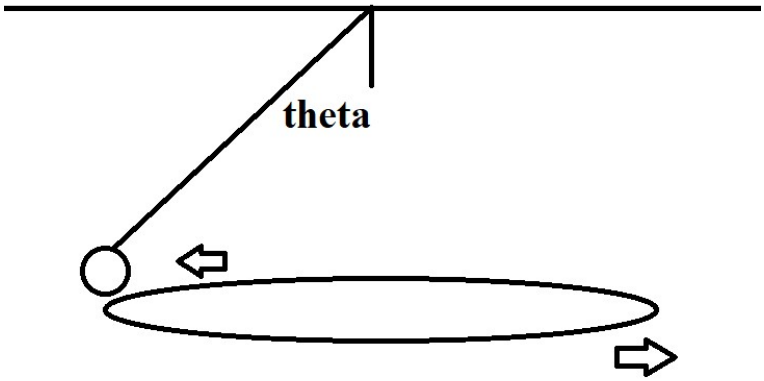
CENTRIFUGEUSE - ROTOR @ FOIRE DU TRONE (GoPro)
josselinz86
https://www.youtube.com/watch?v=GspwbZSjABA

Spinning room amusement park ride
Matt Anderson
https://www.youtube.com/watch?v=h53Vu3BefaQ



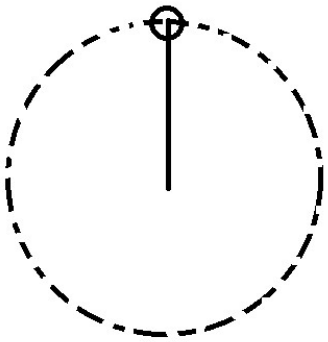
Part 3: Answer the following questions

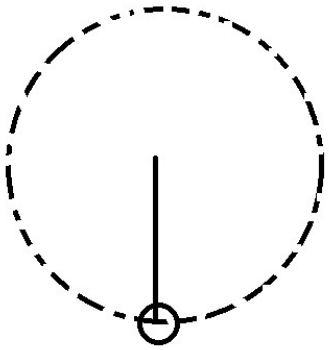
1. Draw a free body diagram and use Newton's second law of motion to obtain an equation for the force of tension and then the speed of a mass on a string in horizontal circular motion which makes an angle θ from the vertical. Your answer should be in terms of the mass of the object *m*, the length of the string *l*, the angle from the vertical *θ*, and the acceleration from gravity *g*.



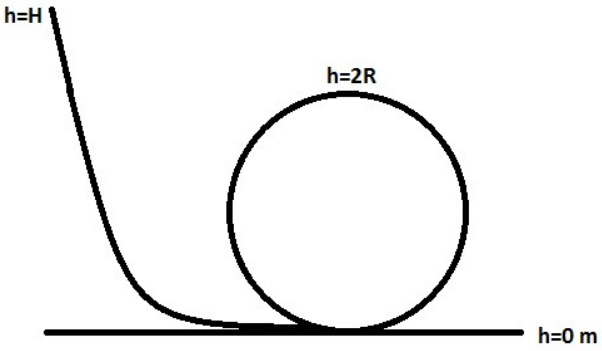
2. A point mass is attached to a massless string with length *r*. The mass and string are moving in vertical circular motion with a constant speed *v*. Draw free body diagrams and use Newton's second law of motion to obtain equations of the force of tension at the top and bottom of the string. Where is the force of tension greater? Your answers should be in terms of the mass of the object *m*, the radius of the string *r*, the speed of the point mass *v*, and the acceleration from gravity *g*.

http://hyperphysics.phy-astr.gsu.edu/hbase/Mechanics/cirvert.html





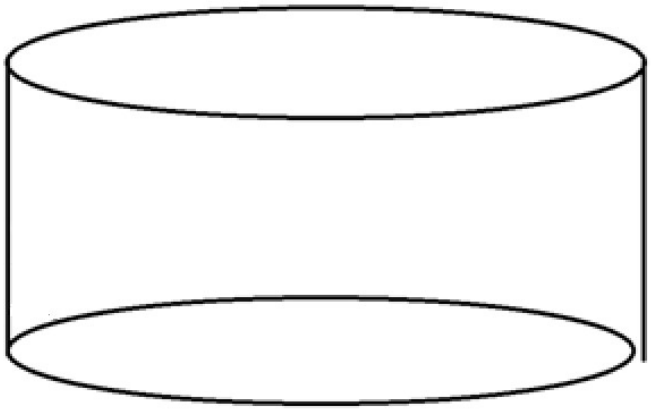
3. An object is released from rest from a height *H*. First use the law of conservation of energy to obtain an equation for the speed of the object when it has reached the top of the loop of the roller coaster. Then use Newton's second law of motion to obtain an equation for the normal force on the object when it has reached the top of the loop of the roller coaster. Your answer for the normal force should be in terms of the mass of the object *m*, the initial height of the object *H*, the radius of the loop *r*, and the acceleration from gravity *g*.



Roller coaster loop the loop
Matt Anderson
https://www.youtube.com/watch?v=upjI5dw8_Es

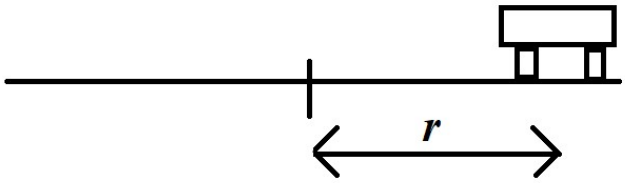
4. Draw a free body diagram and use Newton's second law of motion to obtain an equation for the speed of an object in the amusement park ride "The Well of Death." Your answer should be in terms of the radius of the cylinder/well R, the coefficient of friction μ, and the acceleration from gravity g.

"Mauth Ka Kua" (The Well Of Death): Basic physics at its best!
Swastik Ghosh
https://www.youtube.com/watch?v=cFLNknvi7QE



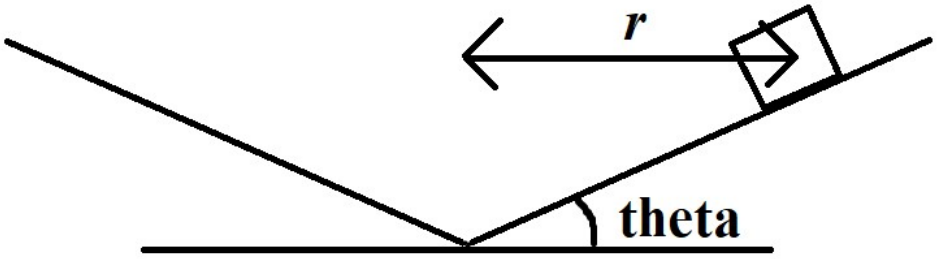
5. Cars

   a. Use Newton's second law of motion to find an equation for the speed of a car moving in circular motion on a horizontal road with surface friction. Your answer should be in terms of the mass of the radius of the track r, the coefficient of friction μ, and the acceleration from gravity g.



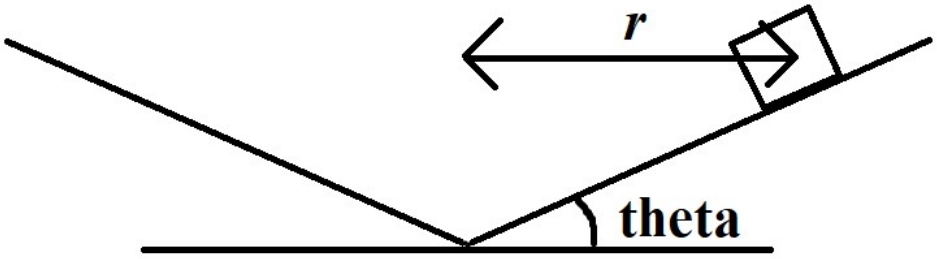
www.batesville.k12.in.us/physics/phynet/mechanics/circular%20motion/banked_with_friction.htm

b. Use Newton's second law of motion to find an equation for the speed of a car moving at an angle θ to the horizontal in circular motion on a banked/angled road with no friction. Your answer should be in terms of the radius of the track *r*, the angle of the banked road *θ*, and the acceleration from gravity *g*.



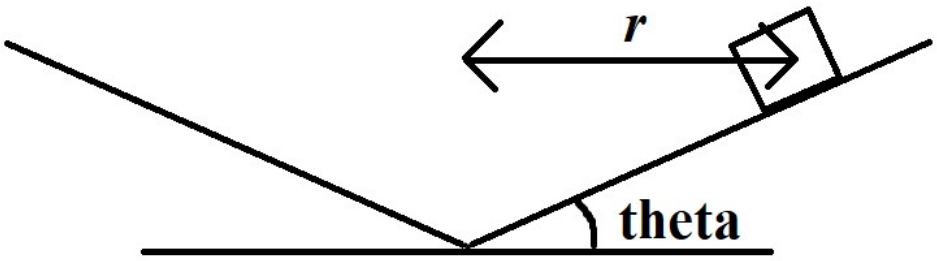
Car on a banked curve
Matt Anderson
https://www.youtube.com/watch?v=sKhu5VTBK_M

c. Use Newton's second law of motion to find an equation for the speed of a slow moving car moving at an angle θ to the horizontal in circular motion on a banked/angled road with surface friction. Your answer should be in terms of the radius of the track r, the angle of the banked road θ, the coefficient of friction μ, and the acceleration from gravity g.



Banked Turns - A Level Physics
DrPhysicsA
https://www.youtube.com/watch?v=8aBkQu_RLlg

d. Use Newton's second law of motion to find an equation for the speed of a fast moving car moving at an angle θ to the horizontal in circular motion on a banked/angled road with surface friction. Your answer should be in terms of the radius of the track r, the angle of the banked road θ, the coefficient of friction μ, and the acceleration from gravity g.



http://hyperphysics.phy-astr.gsu.edu/hbase/Mechanics/carbank.html

Name: _____

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6.2 Newton's Law of Gravitation

Understandings

- Newton's law of gravitation
  http://hyperphysics.phy-astr.gsu.edu/hbase/grav.html#grav
  https://openstax.org/books/university-physics-volume-1/pages/13-1-newtons-law-of-universal-gravitation
- Gravitational field strength
  http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/isq.html#isqg
  https://openstax.org/books/university-physics-volume-1/pages/13-2-gravitation-near-earths-surface

Equations

$$\vec{g} = gravitational\ field\ strength = \frac{\vec{F}}{m_1} = \frac{Gm_2}{r^2}$$

$$\vec{F}_{gravity} = m_1\vec{g} = \frac{Gm_1m_2}{r^2}$$

The solutions can be found on the YouTube channel Go Physics Go:

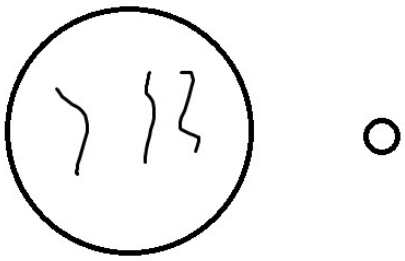
https://www.youtube.com/@gophysicsgo/playlists

Answer the following questions

1. Define *gravitational field strength* $\vec{g} = \frac{\vec{F}}{m} = \frac{Gm_2}{r^2}$. Units?
   http://hyperphysics.phy-astr.gsu.edu/hbase/orbv.html#eg

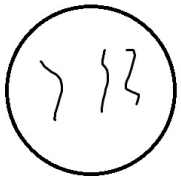
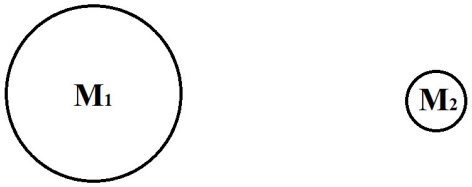
2. Define *Newton's Law of Gravitation* $\vec{F}_g = m_1\vec{g} = \frac{Gm_1m_2}{r^2}$. Units?
   http://hyperphysics.phy-astr.gsu.edu/hbase/grav.html

3. A satellite in space moves in a circle around the Earth with a constant speed at a radius *r* from the center of the Earth. Label the direction of the velocity, force, and acceleration of the satellite in the diagram below.



4. List some rules in drawing gravitational field lines.
   https://diaryofnumbers.blogspot.com/2011_02_01_archive.html
   http://www.mysearch.org.uk/website1/html/339.Laws.html

5. **Use a pencil and ruler!** Draw eight gravitational field lines and four equipotential surfaces for each figure.

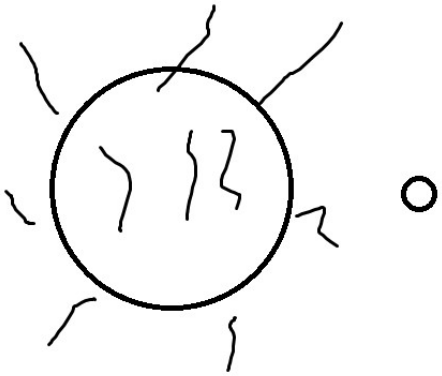
A fixed uniform spherical mass	Two uniform spherical masses with equal mass and equal radius
	
Two fixed uniform spherical masses $M_1 \gg M_2$	
	

6. The force of gravity between a satellite circling the Earth at a distance *r* at a constant speed is F_g. What will happen to the magnitude of the force of gravity between the satellite and the Earth if the satellite moves a distance

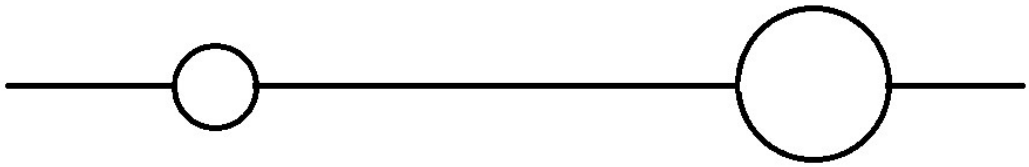
   a. *2r.* b. *3r.* c. *4r.* d. *r/2.* e. *r/3.* f. *r/4.*

7. A satellite is moving in a circle with a constant speed around the sun.
   a. Use Newton's second law of motion to obtain an equation for the speed of the satellite in terms of the mass of the sun M_{sun}, the mass of the satellite $M_{satellite}$, the distance of the satellite to the sun r, and the gravitational constant G.
   b. Use your solution to obtain an equation for the period T of the satellite.

http://hyperphysics.phy-astr.gsu.edu/hbase/orbv.html#co



8. The center of a planet of mass of $m_1 = 4M$ is a distance of $5d$ from the center of a larger planet of mass $m_2 = 9M$. Assume that the mass of the planets can be concentrated at their centers.



What will be the gravitational field strength (both magnitude and direction) at a point

a. *2d* to the left of mass m_1?
b. *2d* to the right of mass m_1?
c. *2d* to the left of mass m_2?
d. *2d* to the right of mass m_2?

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7.1 Discrete Energy and Radioactivity

Understandings

- Discrete energy and discrete energy levels
  https://openstax.org/books/university-physics-volume-3/pages/8-5-atomic-spectra-and-x-rays
- Transitions between energy levels
  https://openstax.org/books/university-physics-volume-3/pages/6-4-bohrs-model-of-the-hydrogen-atom
- Radioactive decay
  https://openstax.org/books/university-physics-volume-3/pages/10-3-radioactive-decay
- Fundamental forces and their properties
  https://openstax.org/books/university-physics-volume-3/pages/11-1-introduction-to-particle-physics
- Alpha particles, beta particles, and gamma rays
  https://openstax.org/books/university-physics-volume-3/pages/10-4-nuclear-reactions
- Half-life
  https://openstax.org/books/university-physics-volume-3/pages/10-3-radioactive-decay
- Absorption characteristics of decay particles
- Isotopes
  http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/nucnot.html#c2
- Background radiation

Equations

$$E = hf$$

$$\lambda = \frac{hc}{E}$$

If you are interested in learning more about atomic, quantum, and nuclear physics then please read the book *The Quantum Story: A History in 40 Moments* by Jim Baggott.

Also watch all the videos in this website:
https://www.learner.org/series/physics-for-the-21st-century/

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Answer the following questions

1. Define *discrete* and *continuous.*
   www.dictionary.com

2. Circle the correct answers in italic font: Free electrons have *continuous/discrete* energy. Bound electrons in an atom have *continuous/discrete* energy.

3. Define *ground state* and *excited state* of an electron in an atom. Draw a figure.
   https://openstax.org/books/college-physics/pages/30-3-bohrs-theory-of-the-hydrogen-atom

4. Define *transition.*
   https://www.dictionary.com

5. Which has more energy: an electron in an atom which is close to its nucleus or an electron in an atom which is farther from its nucleus? Draw a figure.

6. Define *absorption spectra*. What happens to an electron in an atom during *photon absorption*? Draw a figure.
   http://hyperphysics.phy-astr.gsu.edu/hbase/mod5.html
   http://light.physics.auth.gr/enc/wavelength_en.html

7. Define *emission spectrum*. What happens to an electron in an atom during *photon emission*? Draw a figure.
   https://openstax.org/books/university-physics-volume-3/pages/8-5-atomic-spectra-and-x-rays
   https://openstax.org/books/college-physics/pages/29-1-quantization-of-energy

8. We use the equation $E = hf$ for *electromagnetic waves*. Define and give the units of each variable.
   http://hyperphysics.phy-astr.gsu.edu/hbase/mod5.html

9. Define *nucleon.*
   https://www.dictionary.com/browse/nucleon?s=t

10. Define *atomic number Z.*
    http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/nucnot.html

11. Define *mass number A.*

12. Define *nuclide.*
    www.dictionary.com

13. Define *isotope.*
    http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/nucnot.html

14. *Isotopes* have the same _____ properties but different _____ properties.

15. Define *alpha particle*. What is it made of? Charge? Mass?
    http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/radact.html#c2

16. What is the difference between an *alpha particle* and a *helium atom*?

17. Give two examples of *alpha decay*:
    a.

    b.

18. Define *neutrino*. What is it made of? Charge? Mass?
    https://neutrinos.fnal.gov/

19. Define *anti-neutrino*. What is it made of? Charge? Mass?
    https://neutrinos.fnal.gov/

20. Define *positron*. What is it made of? Charge? Mass?
http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/lepton.html

21. Define *beta plus particle*. What is it made of? Charge? Mass?
http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/beta.html#c2

22. What happens to a proton in a decaying nucleus during *beta plus decay*?

23. Give two examples of *beta plus decay*:
    a.

    b.

24. Define *beta minus particle*. What is it made of? Charge? Mass?
http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/beta.html#c2

25. What is the difference between a *beta minus particle* and an *electron*?

26. What happens to a neutron in a decaying nucleus during *beta minus decay*?

27. Give two examples of *beta minus decay*:
    a.

    b.

28. Define *gamma ray*. What is it made of? Charge? Mass?
http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/radact2.html

29. Why is it not correct to use the term *gamma particle*?

30. What is happening to an atom during gamma decay?
    http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/radact2.html#c1

31. Give two examples of *gamma decay*:
    a.

    b.

32. Define *ionization*
http://hyperphysics.phy-astr.gsu.edu/hbase/mod4.html#c3

33. Define *to penetrate.*
    www.dictionary.com

34. Define *penetrating power*. Which object can we use to stop an *alpha particle*? A *beta particle*? A *gamma ray*?
    http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/radact.html#c3

35. Why do stable nuclei have more neutrons than protons?

36. Define *random* and *spontaneous.*
    www.distionary.com

37. *Radioactive decay* is both _____ and _____.

38. Define *half-life*. Units?
https://openstax.org/books/college-physics/pages/31-5-half-life-and-activity
http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/halfli.html#c1

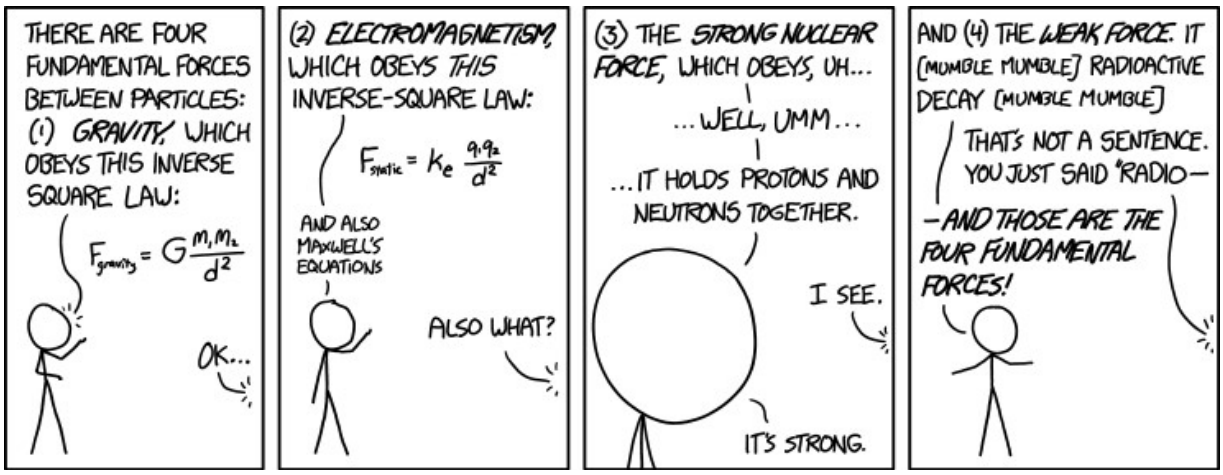
39. Define *activity*. Units? Use a **pencil and ruler!** Draw an activity vs. time graph for a radioactive element.
https://openstax.org/books/college-physics/pages/31-5-half-life-and-activity

40. Define *background radiation.*
https://openstax.org/books/college-physics/pages/32-2-biological-effects-of-ionizing-radiation

41. Complete the table below:
https://openstax.org/books/college-physics/pages/33-2-the-four-basic-forces
http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/funfor.html

Fundamental force	Relative strength?	What does it act on?	What is its range?	Carrier particle?

42. Describe the weak force.
http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/unify.html



https://xkcd.com/1489/

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7.2 Nuclear Reactions

Understandings

- The unified atomic mass unit
  http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/nucuni.html#c1
  https://openstax.org/books/university-physics-volume-3/pages/10-1-properties-of-nuclei
- Mass defect and nuclear binding energy
  http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/nucbin.html#c2
  https://openstax.org/books/university-physics-volume-3/pages/10-2-nuclear-binding-energy
- Nuclear fission and nuclear fusion
  http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fission.html#c1
  http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fusion.html#c1
  https://openstax.org/books/university-physics-volume-3/pages/10-5-fission
  https://openstax.org/books/university-physics-volume-3/pages/10-6-nuclear-fusion

Equations

$\Delta E = \Delta m \times c^2$

The Evil Revealed in First US Nuclear Test: 74 Years Ago Over Bikini
https://www.activistpost.com/2020/06/the-evil-revealed-in-first-us-nuclear-test-74-years-ago-over-bikini.html

MIT Scientists: Nuclear Fusion Energy Could Be Closer Than Thought
https://oilprice.com/Alternative-Energy/Nuclear-Power/MIT-Scientists-Nuclear-Fusion-Energy-Could-Be-Closer-Than-Thought.html

Nuclear War Survival Skills
http://nuclearwarsurvivalskills.com/

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Answer the following questions

1. Define *atomic mass unit*. Units?
   http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/nucuni.html
   https://openstax.org/books/college-physics/pages/31-3-substructure-of-the-nucleus

2. Which has more mass: two individual protons or two protons in the same nucleus?

3. Define *mass defect*. Units?
   https://openstax.org/books/university-physics-volume-3/pages/10-2-nuclear-binding-energy

4. Define *binding energy*. Units?
   https://openstax.org/books/university-physics-volume-3/pages/10-2-nuclear-binding-energy
   http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/nucbin.html

5. **Use a pencil and ruler!** Draw and label the *binding energy curve*. Label the horizontal and vertical axis. Label the most stable element.
   https://openstax.org/books/college-physics/pages/31-6-binding-energy
   http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/nucbin.html

6. Use the equation $\Delta E = \Delta m \times c^2$ to find the energy equivalent of 1 amu in Joules and $\mathrm{MeV/c^2}$.

7. Define *transmutation.*
   https://www.nuclear-power.net/nuclear-power/reactor-physics/reactor-operation/fuel-burnup/nuclear-transmutation/
   https://byjus.com/physics/artificial-transmutation/

8. What happens in nuclear decay if the *mass difference* is positive? Is nuclear decay possible?
   https://openstax.org/books/college-physics/pages/31-4-nuclear-decay-and-conservation-laws

9. What happens in nuclear decay if the *mass difference* is negative? Is nuclear decay possible?
   https://openstax.org/books/college-physics/pages/31-4-nuclear-decay-and-conservation-laws

10. Define *nuclear fission.*
    https://openstax.org/books/college-physics/pages/32-6-fission
    http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fission.html

11. Give two examples of *nuclear fission*:
    https://www.nuclear-power.com/nuclear-power/fission/
    a.

    b.

12. Define *chain reaction.*
    https://openstax.org/books/college-physics/pages/32-6-fission
    http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/U235chn.html

13. Define *critical mass*. Units?
    https://openstax.org/books/college-physics/pages/32-6-fission
    http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/moder.html

14. Define *induced fission process.*
    https://openstax.org/books/college-physics/pages/32-6-fission
    http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fission.html

15. Define *nuclear fusion.*
    https://openstax.org/books/university-physics-volume-3/pages/10-6-nuclear-fusion
    http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fusion.html

16. Give two examples of *nuclear fusion*:
    a.

    b.

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7.3 The Structure of Matter

Understandings

- Quarks, leptons, and their antiparticles
  http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/parcon.html
  https://openstax.org/books/university-physics-volume-3/pages/11-3-quarks
- Hadrons, baryons, and mesons
  http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/parcon.html
- The conservation laws of charge, baryon number, lepton number, and strangeness
  http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/parint.html#c2
  https://openstax.org/books/university-physics-volume-3/pages/11-2-particle-conservation-laws
- The nature and range of the strong nuclear force, weak nuclear force, and electromagnetic force
  http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/funfor.html#c2
- Exchange particles
  http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/expar.html#c6
- Feynman diagrams
  http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/expar.html#c2
  https://openstax.org/books/university-physics-volume-3/pages/11-5-the-standard-model
- Confinement
  http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/quark.html#c6
  https://openstax.org/books/university-physics-volume-3/pages/11-3-quarks
- The Higgs boson
  http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/higgs.html#c1
  https://openstax.org/books/university-physics-volume-3/pages/11-1-introduction-to-particle-physics

Charge	Quarks			Baryon number
$\frac{2}{3}e$	u	c	t	$\frac{1}{3}$
$-\frac{1}{3}e$	d	s	b	$\frac{1}{3}$
All quarks have a strangeness number of 0 except the strange quark that has a strangeness number of –1				

Charge	Leptons		
–1	e	μ	τ
0	ν_e	ν_μ	ν_τ
All leptons have a lepton number of 1 and antileptons have a lepton number of –1			

	Gravitational	Weak	Electromagnetic	Strong
Particles experiencing	All	Quarks, leptons	Charged	Quarks, gluons
Particles mediating	Graviton	W^+, W^-, Z^0	γ	Gluons

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. Draw and describe the main points of the *Thomson model of the atom*: http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/rutsca3.html#c2

2. What happened to the alpha particles in the *Rutherford gold leaf experiment*? http://hyperphysics.phy-astr.gsu.edu/hbase/rutsca.html#c1
   a.

   b.

3. Draw the *Rutherford model of the atom*:

4. True or false: Your brain is mostly empty space.

5. Approximately which year were the following particles discovered?

Electron	Proton	Neutron
Atomic nucleus	Photon	Neutrino

6. Define *elementary particle.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/parsea.html#c1

7. Define *quark*. Which types of quantum numbers (or conservation laws) do *quarks* have? In the first table state the six types/flavors of *quarks*. In the second table state the six types/flavors of *antiquarks*.
   http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/quark.html
   https://openstax.org/books/university-physics-volume-3/pages/11-3-quarks

8. Define *quark confinement.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/quark.html#c6
   https://openstax.org/books/university-physics-volume-3/pages/11-3-quarks

9. Define the following terms:
   http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/hadron.html
   https://openstax.org/books/university-physics-volume-3/pages/11-1-introduction-to-particle-physics

   a. hadron

   b. meson

   c. baryon

10. Define *lepton*. Which types of quantum numbers (or conservation laws) do *leptons* have? In the first table state the six types of *leptons*. In the second table state the six types of *antileptons*.
http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/lepton.html
https://openstax.org/books/university-physics-volume-3/pages/11-1-introduction-to-particle-physics

11. Define *exchange particle*. In the table state the exchange particle(s) for each force.
http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/exchg.html#c1
http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/expar.html
https://openstax.org/books/university-physics-volume-3/pages/11-5-the-standard-model

Electromagnetic	Gravitational	Strong	Weak

12. *Short lifetimes* ($10^{-25}\ s$) imply the _____ interaction. *Long lifetimes* ($10^{-10}\ s$) imply the _____ interaction.
http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/lambda.html

13. State some characteristics of and differences between a *particle* and its *antiparticle*.
http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/antimatter.html

14. Complete the following table:

Particle	Antiparticle
Proton (2 up quarks, 1 down quark) uud	
Neutron (1 up quark, two down quarks) udd	
Electron	
Photon	
Neutrino	

15. Complete the following table:

	Electron	Antielectron (positron)
Mass		
Charge		
Baryon number		
Lepton number		
Strangeness number		

16. A particle moving forward in time is mathematically equivalent to an _____ moving backwards in time.

17. What is the *Standard Model of Particle Physics?*
http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/funfor.html

18. Describe the *Higgs particle* (*Higgs boson*).
    http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/higgs.html

19. Draw a Feynman diagram showing a neutron decay to a proton, a beta minus particle (electron), and an antineutrino. This is called beta minus decay.

20. Draw a Feynman diagram showing a proton decay to a neutron, a beta plus particle (positron), and a neutrino. This is called beta plus decay.

Part 2: Watch and take notes on the following video:

12-feynman diagrams
Reed Jeffrey
https://www.youtube.com/watch?v=pJGEH_vDnGw

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8.1 Energy Sources

Understandings

- Specific energy and energy density of fuel sources
- Sankey diagrams
  http://sankeymatic.com/
- Primary energy sources
  https://energyeducation.ca/encyclopedia/Primary_energy
- Electricity as a secondary and versatile form of energy
  https://energyeducation.ca/encyclopedia/Secondary_energy
- Renewable and non-renewable energy sources
  https://energyeducation.ca/encyclopedia/Renewable_and_sustainable_energy

Equations

$$Power = \frac{Energy}{time}$$

$$Power = \frac{1}{2} A \rho v^3$$

Planet of the Humans
https://planetofthehumans.com/

Are EVs Good For The Environment? ...Mostly Not
https://www.zerohedge.com/technology/are-evs-good-environment-mostly-not

The "Battery Fairy" & Other Delusions in the Race to Replace Gas-Powered Cars
https://www.zerohedge.com/energy/battery-fairy-other-delusions-race-replace-gas-powered-cars

Achtung Baby (It's Cold Outside) – Germany's "Green" Energy Fail Rescued By Coal and Gas
https://www.zerohedge.com/technology/achtung-baby-its-cold-outside-germanys-green-energy-fail-rescued-coal-and-gas

"Super Emitters": 1% Of People Cause Half Of Global Aviation Emissions
https://austrian.economicblogs.org/zerohedge/2020/durden-emitters-global-aviation-emissions/

The 10 Most Insane Requirements of the Green New Deal
https://thefederalist.com/2019/02/07/ten-most-insane-requirements-green-new-deal/

California EV Mandate Could "Lead To Disaster" For State's Already Fragile Electric Grid
https://www.activistpost.com/2020/09/california-ev-mandate-could-lead-to-disaster-for-states-already-fragile-electric-grid.html

The Holy Grail of Endless Energy: Harvesting Blackholes
https://oilprice.com/Energy/Energy-General/The-Holy-Grail-of-Endless-Energy-Harvesting-Blackholes.html

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Answer the following questions

1. What are the three most popular sources of energy?
   https://www.visualcapitalist.com/worlds-largest-energy-sources/

2. Define *primary energy*. Give an example.
   https://www.nuclear-power.net/nuclear-engineering/thermodynamics/what-is-energy-physics/primary-energy-sources/

3. Define *secondary energy*. Give an example.
   https://www.eniscuola.net/en/argomento/energy-knowledge/energy-sources/primary-and-secondary-sources/

4. Define *specific energy*. What are its units?
   https://www.youtube.com/watch?v=h5_Wiy0HazM

5. Define *energy density*. What are its units?

6. Define and give three examples of *non-renewable energy sources.*
   https://openstax.org/books/university-physics-volume-1/pages/8-5-sources-of-energy

7. Define and give three examples of *renewable energy sources.*

8. Define and give two examples of *biofuels*.
   https://phys.org/tags/biofuel/

9. Define and give three examples of *fossil fuels*. How long does it take to create *fossil fuels*? State two advantages and two disadvantages to using *fossil fuels*.
   https://www.miniphysics.com/fossil-fuels.html

10. What are some characteristics in a *Sankey diagram*? Sketch a simple *Sankey diagram*.
    http://sankeymatic.com/

11. Define *efficiency*. State its equation and units.
    https://openstax.org/books/college-physics/pages/7-6-conservation-of-energy

12. What is the *efficiency* for coal, natural gas, and oil power plants?
    https://geospatial.blogs.com/geospatial/2010/01/energy-efficiency-of-fossil-fuel-power-generation.html

13. What are the uses of the following objects in a nuclear reactor?
    a. *moderator*
    https://www.nuclear-power.com/neutron-moderator/

    b. *fuel rod*
    https://www.nuclear-power.com/nuclear-power-plant/nuclear-fuel/fuel-assembly/fuel-rods-fuel-pins/

    c. *heat exchanger*
    https://www.nuclear-power.com/nuclear-engineering/heat-transfer/heat-exchangers/example-calculation-of-heat-exchanger/

    d. *control rod*
    https://www.nuclear-power.com/nuclear-power-plant/control-rods/

14. State two benefits and two drawbacks to using *nuclear power.*

15. State two benefits and two drawbacks to using *solar energy.*

16. What does a *solar heating panel* do?
    https://www.bbc.co.uk/bitesize/guides/zsmpk7h/revision/5

17. What does a *photovoltaic cell* do?
    https://energyeducation.ca/encyclopedia/Photovoltaic_cell

18. Define *hydro.*
    www.dictionary.com

19. What is *hydroelectric power*? State two benefits and two drawbacks.
https://www.usgs.gov/special-topic/water-science-school/science/hydroelectric-power-how-it-works?qt-science_center_objects=0#qt-science_center_objects

20. What is a *pumped storage system*? State two benefits and two drawbacks.
https://www.usgs.gov/special-topic/water-science-school/science/hydroelectric-power-how-it-works?qt-science_center_objects=0#qt-science_center_objects

21. What is *wind power*? State two benefits and two drawbacks.
https://www.energy.gov/eere/wind/how-do-wind-turbines-work

22. For which object can we use the equation $P = \frac{1}{2}A\rho v^3$? Define each term in the equation. What are some assumptions to using the equation?

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8.2 Thermal Energy Transfer

Understandings

- Conduction, convection, and thermal radiation
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/stefan.html#c2
  https://openstax.org/books/university-physics-volume-2/pages/1-6-mechanisms-of-heat-transfer
- Black-body radiation
  http://hyperphysics.phy-astr.gsu.edu/hbase/mod6.html#c1
  https://openstax.org/books/university-physics-volume-3/pages/6-1-blackbody-radiation
- Albedo and emissivity
  http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/albedo.html#c1
- The solar constant
  https://pages.mtu.edu/~raman/SilverI/MiTEP_ESI-2/Solar_Constant.html
- The greenhouse effect
  http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
- Energy balance in the Earth surface-atmosphere system
  http://www.climate.be/textbook/pdf/Chapter_2.pdf

Equations

$$P = e\sigma AT^4$$

$$\lambda_{max} = \frac{2.90\times10^{-3}}{T}$$

$$I = \frac{Power}{Area}$$

$$albedo = \frac{total\ scattered\ power}{total\ incident\ power}$$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Answer the following questions

1. What is the difference between a *thermal conductor* and *thermal insulator*? Give an example of each.

2. Define *conduction, convection,* and *radiation.* Give an example of each. https://www.thermal-engineering.org/what-is-conduction-convection-radiation-definition/

3. Define *absorb*, *reflect*, and *emit.* www.dictionary.com

4. Define *black body.* http://hyperphysics.phy-astr.gsu.edu/hbase/mod6.html

5. What does *Stefan-Boltzmann law* tell us? State the equation and define each variable in *Stefan-Boltzmann law*. http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/stefan.html

6. State the definition, equation, and units for *emissivity*. What is the *emissivity* of a really dark colored object? What is the *emissivity* of a really light colored object?
https://openstax.org/books/college-physics/pages/14-7-radiation

7. What does *Wien's displacement law* tell us? State the equation and define each variable for *Wien's displacement law*. Draw and label a graph describing *Wien's displacement law*.
https://openstax.org/books/university-physics-volume-3/pages/6-1-blackbody-radiation

8. What is the equation and what are the units for *intensity*?

$$Intensity = \frac{Power}{Area} = \left[\frac{Watts}{m^2}\right]$$

9. What is the meaning, value, and units of the Sun-Earth *solar constant*?
http://hyperphysics.phy-astr.gsu.edu/hbase/vision/solirrad.html

10. State the definition, equation, and units for *albedo*. What is the *albedo* of a really dark colored object? What is the *albedo* of a really light colored object?
http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/albedo.html

11. What is the mathematical relationship between the *emissivity* and *albedo* of an object?

$$emissivity + albedo = 1$$

12. Define *greenhouse effect*. What are the four major *greenhouse gases*? State their name and chemical formula.
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatra.html
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/grnhse.html#c1

Part 2: Browse these websites for more information on climate change

The world's most viewed site on global warming and climate change
www.wattsupwiththat.com

Climate Depot: Redefining Global Warming Reporting
www.climatedepot.com

Climate Hustle
https://www.climatehustle.org/

Climate Hustle 2
https://www.climatehustle2.com/

Lockdown Proponent Bill Gates Quietly Funding Plan to Dim the Sun's Rays
https://www.newswars.com/lockdown-proponent-bill-gates-quietly-funding-plan-to-dim-the-suns-rays/

Forbes Censors Award-Winning Environmentalist's Apology Over Three-Decade 'Climate Scare' – So Here It Is
https://www.theburningplatform.com/2020/06/29/forbes-censors-award-winning-environmentalists-apology-over-three-decade-climate-scare-so-here-it-is/

Scientists Find 'Man-made Climate Change Doesn't Exist In Practice'
https://www.climatedepot.com/2019/07/12/scientists-find-man-made-climate-change-doesnt-exist-in-practice/

Glacier National Park Quietly Removes Its 'Gone by 2020' Signs
https://wattsupwiththat.com/2019/06/07/glacier-national-park-quietly-removes-its-gone-by-2020-signs/

Let's Review 50 Years of Dire Climate Forecasts And What Actually Happened
https://www.zerohedge.com/political/lets-review-50-years-dire-climate-forecasts-and-what-actually-happened

Let's Review 50 Years of Dire Climate Forecasts and What Actually Happened
https://www.thestreet.com/mishtalk/economics/lets-review-50-years-of-dire-climate-forecasts-and-what-actually-happened

Drought Reveals Medieval "Hunger Stones" in European Rivers
https://www.odditycentral.com/news/drought-reveals-medieval-hunger-stones-in-european-rivers.html

Part 3: Watch and take notes on the following videos

Albedo
Swahson Does Science
https://www.youtube.com/watch?v=6gOE0fi5-lQ

Blackbody Radiation: the Laws of Stefan, Wien, and Planck!
Sky Scholar
https://www.youtube.com/watch?v=h5jOAw57OXM

Wien's Displacement Law - A Level Physics
VTPhysics
https://www.youtube.com/watch?v=qjM73TlVkTo

Weins Displacement Law
Tutorials Point (India) Ltd.
https://www.youtube.com/watch?v=j1asaL_5vhk

IB Physics: Climate Concepts
Chris Doner
https://www.youtube.com/watch?v=slf3ka8N4xQ

IB Physics: Energy Balance Climate Model & Greenhouse Effect
Chris Doner
https://www.youtube.com/watch?v=riv7ewVpUMI

IB Physics - Topic 8.2 - Handout 2 Solutions
Ryan Van Loh
https://www.youtube.com/watch?v=odPGygQCxoc