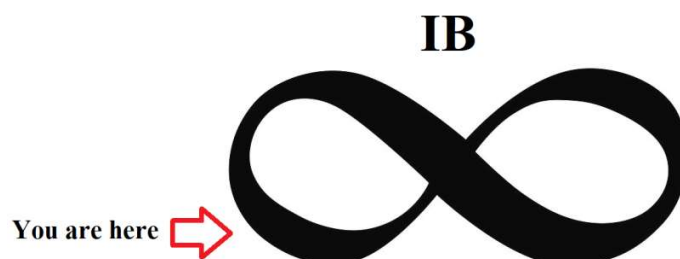


IB Physics HL Worksheets

9.1-12.2



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=4oW3tWYlpw>

Marty Lobdell - Study Less Study Smart

PierceCollegeDist11

<https://www.youtube.com/watch?v=IIU-zDU6aQ0>

Scientifically Proven Best Ways to Study

The Infographics Show

<https://www.youtube.com/watch?v=VJbKXmujI00>

Name: _____

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9.1 Simple Harmonic Motion

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/diffracon.html#c1>

Understandings

- The defining equation of SHM
- Energy changes

Equations

$$\omega = \frac{2\pi}{T}$$

$$a = -\omega^2 x$$

$$x = x_0 \sin \omega t; x = x_0 \cos \omega t$$

$$v = \omega x_0 \cos \omega t; v = -\omega x_0 \sin \omega t$$

$$v = \pm \omega \sqrt{x_0^2 - x^2}$$

$$E_K = \frac{1}{2} m \omega^2 (x_0^2 - x^2)$$

$$E_T = \frac{1}{2} m \omega^2 x_0^2$$

$$\text{Pendulum: } T = 2\pi \sqrt{\frac{l}{g}}$$

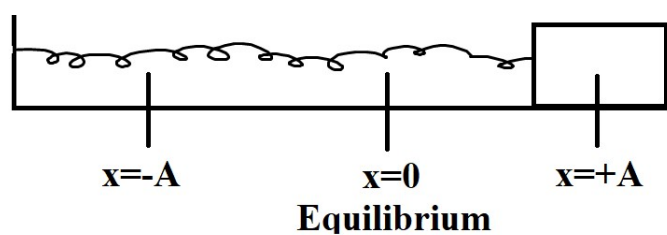
$$\text{Mass-spring: } T = 2\pi \sqrt{\frac{m}{k}}$$

Part 1: Review section 4.1

Part 2: Watch and take notes on my video on this section. The video can be found on the YouTube channel Go Physics Go:

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

For a mass on a spring:



1		
2		
3		
4		
5		
6		
7		

Part 3: Optional for math lovers

The small angle approximation ($\theta < 10^\circ$) for the period of a pendulum is given in the physics data booklet: $T = 2\pi\sqrt{\frac{l}{g}}$

The exact solution is given from the video below:

Exact Solution of the Nonlinear Pendulum

Flammable Maths

<https://www.youtube.com/watch?v=efvT2iUSjaA>

Name: _____

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9.2 Single-Slit Diffraction

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/diffrac.html#c1>

Understandings

- The nature of single-slit diffraction

Equations

$$\theta = \frac{\lambda}{b}$$

Part 1: Review section 4.4 on single slit diffraction

Part 2: Answer the following questions

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

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

1. **Use a pencil!** Draw the lab setup and the intensity vs. distance graph for single slit diffraction.

<https://openstax.org/books/university-physics-volume-3/pages/4-1-single-slit-diffraction>

2. Derive the equation $\theta = \lambda/b$.

<https://openstax.org/books/university-physics-volume-3/pages/4-1-single-slit-diffraction>

3. What will happen to the thickness of the central maximum $2\theta = \frac{2\lambda}{b}$ if
- the wavelength λ of a wave passing through a single slit is increased?
 - the wavelength λ of a wave passing through a single slit is decreased?
 - the opening of a single slit b is increased?
 - the opening of a single slit b is decreased?
4. What happens when white light passes through a single slit?

Name: _____

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9.3 Interference

Understandings

- Young's double-slit experiment
- Modulation of two-slit interference pattern by one-slit diffraction effect
- Multiple slit and diffraction grating interference patterns
- Thin film interference

Equations

$$n\lambda = d \sin \theta$$

$$\text{Constructive interference: } 2dn = (m + \frac{1}{2})\lambda$$

$$\text{Destructive interference: } 2dn = m\lambda$$

This is the most difficult section in topic 9! Please take a long time to learn this section and go through as many examples as possible!

Part 1: Review section 4.4 on interference and diffraction**Part 2: Watch and take notes on the following videos****Diffraction interference patterns with phasor diagrams**

Physics Videos by Eugene Khutoryansky

<https://www.youtube.com/watch?v=NazBRcMDOOo>**9.3.1 Double and Multiple Slit Diffraction (1-10)**

MrSmithsPhysics

<https://www.youtube.com/watch?v=4EpLk4I8ecY>

Part 3: Answer the following questions

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

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

1. **Use a pencil!** Draw the lab setup and the intensity vs. displacement graph for Young's double slit experiment.

<https://openstax.org/books/university-physics-volume-3/pages/3-1-youngs-double-slit-interference>

2. State the equation for double slit constructive interference and define each variable.

<https://openstax.org/books/university-physics-volume-3/pages/3-1-youngs-double-slit-interference>

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/slits.html#c1>

3. State the equation for double slit destructive interference and define each variable.

<https://openstax.org/books/university-physics-volume-3/pages/3-1-youngs-double-slit-interference>

4. What happens to the intensity pattern as the number of slits increases?

<https://openstax.org/books/university-physics-volume-3/pages/3-3-multiple-slit-interference>

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/mulslid.html#c3>

5. **Use a pencil and ruler!** Carefully draw an *intensity vs. distance* graph for the following number of slits:

<https://openstax.org/books/university-physics-volume-3/pages/3-3-multiple-slit-interference>

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/mulslid.html#c3>

One slit
Two slits
Three slits

Four slits
Five slits
Six slits

6. What is a *diffraction grating*? What is its purpose?

<https://openstax.org/books/university-physics-volume-3/pages/4-4-diffraction-gratings>

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/gratint.html#c1>

7. Describe the meaning of the single slit *envelope*.

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/mulslid.html#c3>

The *intensity vs. distance* graph for multiple slits is within a single slit pattern. The single slit pattern is like an envelope which contains the multiple slit graph inside it.

Part 4: Review section 4.4 on reflection and refraction

Part 5: Watch and take notes on the following videos

Thin Film Interference Summary

mrwaynesclass

<https://www.youtube.com/watch?v=lpSGC57nsg0>

27 Inteference & Diffraction - Thin film interference

Cogverse Academy

<https://www.youtube.com/watch?v=vxh0yiw4Z8I>

Physics - Interference of Light (5 of 8) The Thin Film

Michel van Biezen

<https://www.youtube.com/watch?v=7zWqU4QSIg4>

Physics - Interference of Light (6 of 8) The Thin Film: Oil

Michel van Biezen

https://www.youtube.com/watch?v=g2uETbwBQ_Q

Physics - Interference of Light (7 of 8) The Thin Film

Michel van Biezen

<https://www.youtube.com/watch?v=bCjPN42-95o>

IB Physics: Thin Films

Chris Doner

<https://www.youtube.com/watch?v=bnLAXh-rQAc>

Thin Film Interference

MindSportPhysics

<https://www.youtube.com/watch?v=FvThwAq2WK8>

Part 6: Answer the following questions

8. Describe the phenomenon of *thin film interference* using the videos from part 5 above and the links below.

<https://openstax.org/books/university-physics-volume-3/pages/3-4-interference-in-thin-films>

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/thinfilm.html>

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/interf.html>

Case 1: Obtain an equation for constructive interference and destructive interference when $n_1 > n_2$ and $n_2 > n_3$.

Case 2: Obtain an equation for constructive interference and destructive interference when $n_1 > n_2$ and $n_2 < n_3$.

Case 3: Obtain an equation for constructive interference and destructive interference when $n_1 < n_2$ and $n_2 > n_3$.

Case 4: Obtain an equation for constructive interference and destructive interference when $n_1 < n_2$ and $n_2 < n_3$.

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9.4 Resolution

Understandings

- The size of a diffracting aperture
- The resolution of simple monochromatic two-source systems

Equations

$$\theta = 1.22 \frac{\lambda}{b}$$

$$R = \frac{\lambda}{\Delta\lambda} = mN$$

Part 1: Review single slit diffraction from sections 4.4 and 9.1

Part 2: Watch and take notes on the following videos

9.4.1 Resolution (1-13)

MrSmithsPhysics

<https://www.youtube.com/watch?v=hrwWajj121g>

**The Rayleigh Criterion | Diffraction-Limited Vision and Photography | Doc
Physics**

Doc Schuster

<https://www.youtube.com/watch?v=ef211FCx1fs>

IB Physics - Topic 9.4 - Resolution

Ryan Van Loh

<https://www.youtube.com/watch?v=KayPidS2v0Q>

27 Inteferece & Diffraction - Rayleigh criterion

Cogverse Academy

https://www.youtube.com/watch?v=antnPm4z8_c

27 Inteferece & Diffraction - Diffraction grating

Cogverse Academy

https://www.youtube.com/watch?v=N5uUsCC3U_w

Part 3: Use your favorite resources to answer the following questions

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

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

1. Define *resolution*

www.dictionary.com

2. Define *Rayleigh Criterion*

<https://openstax.org/books/university-physics-volume-3/pages/4-5-circular-apertures-and-resolution>

<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/Raylei.html>

3. **Use a pencil!** Define and give the units of each variable in the equation

$\theta = 1.22 \frac{\lambda}{b}$. What does this equation tell us? Draw a labeled figure.

4. Two green dots on a white wall are separated by two centimeters. At which distance can an adult human resolve these two green dots? The adult human has a pupil diameter of 4 mm. The wavelength of green light is around 530 nm. Treat the two green dots as point sources.
5. What is the minimum separation distance of two red dots on a white wall to be resolvable from 100 m away? The adult human has a pupil diameter of 4 mm. The wavelength of red light is around 700 nm. Treat the two red dots as point sources.
6. **Use a pencil!** Define and give the units of each variable in the equation $R = \frac{\lambda}{\Delta\lambda} = mN$. What does this equation tell us? Draw a labeled figure.
<http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/gratres.html>

Name: _____

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9.5 Doppler Effect

Understandings

- The Doppler effect for sound waves and light waves

Equations

$$\text{Moving source: } f' = f \left(\frac{v}{v \pm u_s} \right)$$

$$\text{Moving observer: } f' = f \left(\frac{v \pm u_o}{v} \right)$$

$$\frac{\Delta f}{f} = \frac{\Delta \lambda}{\lambda} \approx \frac{v}{c}$$

Part 1: Watch and take notes on the following videos**IB Physics - The Doppler Effect (Unit 9.5)**

IB Physics with Mr. Finnegan

<https://www.youtube.com/watch?v=Qn6iDNunc58>**14 - Mechanical waves - Doppler effect**

Cogverse Academy

<https://www.youtube.com/watch?v=NB-du0vL83w>**The Doppler Effect | Physics with Professor Matt Anderson | M25-14**

Physics with Professor Matt Anderson

<https://www.youtube.com/watch?v=Y3uuaFJefCI>**How To Solve Doppler Effect Physics Problems**

The Organic Chemistry Tutor

<https://www.youtube.com/watch?v=WiTQxNaKAYA>

Part 2: Use your favorite resources to answer the following questions

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

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

1. Define *Doppler effect*.

<https://openstax.org/books/university-physics-volume-1/pages/17-7-the-doppler-effect>

<http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/dopp.html>

2. **Use a pencil!** Draw a wavefront diagram for a moving source and stationary observer in front of the source and behind the source.

<https://interestingengineering.com/what-is-the-doppler-effect-and-how-is-it-used-in-real-life>

3. **Use a pencil!** Draw a wavefront diagram for a stationary source and moving observer in front of the source and behind the source.

<https://pixels.com/featured/doppler-effect-illustration-spencer-sutton.html>

4. Late to class! Usain Bolt runs towards his physics class with a constant speed of 9.58 m/s while blasting music from his boom box which emits a frequency of 440 Hz. What is the observed frequency and wavelength detected by the students in his physics classroom? The speed of sound in air at sea level is approximately 340.29 m/s.

5. Class ends! Usain Bolt runs away from his physics class towards the cafeteria with a constant speed of 9.58 m/s while blasting music from his boom box which emits a frequency of 440 Hz. What is the observed frequency and wavelength detected by the students in his physics classroom? The speed of sound in air at sea level is approximately 340.29 m/s.

6. Late to class! Usain Bolt runs towards his physics class with a constant speed of 9.58 m/s. He can hear his physics teacher lecturing with frequency of 440 Hz. What is the observed frequency and wavelength detected by Usain Bolt as he is running towards his physics class? The speed of sound in air at sea level is approximately 340.29 m/s.
7. Class ends! Usain Bolt runs away from his physics class to the cafeteria with a constant speed of 9.58 m/s. He can hear his teacher continue to lecture with frequency of 440 Hz. What is the observed frequency and wavelength detected by Usain Bolt as he is running towards the cafeteria? The speed of sound in air at sea level is approximately 340.29 m/s.
8. Describe the equation $\frac{\Delta f}{f} = \frac{\Delta \lambda}{\lambda} \approx \frac{v}{c}$ and define each variable.

9. Describe the term *red shift*.

<https://openstax.org/books/university-physics-volume-3/pages/5-7-doppler-effect-for-light>

10. Describe the term *blue shift*.

11. Describe the term *expanding universe*.

<https://openstax.org/books/university-physics-volume-3/pages/11-6-the-big-bang>

<http://hyperphysics.phy-astr.gsu.edu/hbase/Astro/hubble.html>

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10.1 Describing Fields

Understandings

- Gravitational fields
- Electrostatic fields
- Electric potential and gravitational potential
- Field lines
- Equipotential surfaces

Equations

$$W = q\Delta V_e$$

$$W = m\Delta V_g$$

Equation not given in IB Physics Data Booklet

$$V = Ed$$

Important! *Gravitational potential* and *gravitational potential energy* are not the same! Compare the definitions, equations, and units!

Important! *Electric potential* and *electric potential energy* are not the same! Compare the definitions, equations, and units!

Part 1: Review the videos from sections 2.2, 5.1, 6.1, and 6.2

Part 2: Use your favorite sources to answer the following questions

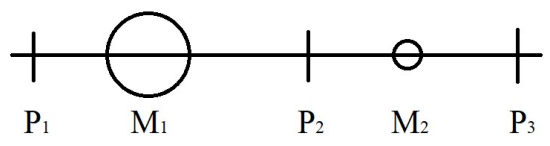
The solutions can be found on the YouTube channel Go Physics Go:

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

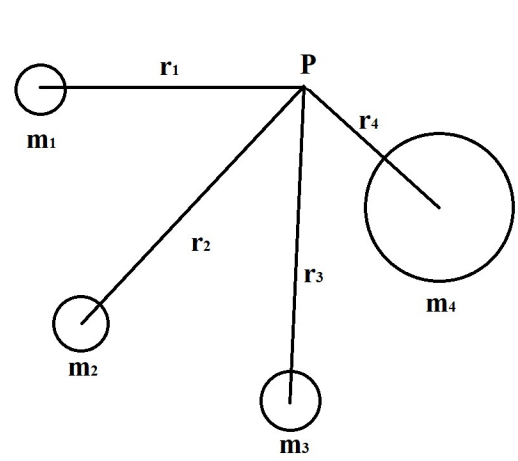
1. The following problem refers to *gravitational field strength*.
<https://openstax.org/books/university-physics-volume-1/pages/13-2-gravitation-near-earths-surface>
http://www.studyphysics.ca/2007/20/02_dynamics/30_field_strength.pdf
 - a. Define *gravitational field strength*. Is it a scalar or a vector?
 - b. What is the equation and what are the units for *gravitational field strength*? Define and give the units of each variable.
 - c. Where is the *gravitational field strength* zero? Where is the *gravitational field strength* maximum?
 - d. What are the mathematical limits of *gravitational field strength*? Can *gravitational potential* be positive? Negative? Zero?

How to calculate/determine/measure the gravitational field strength:

Example 1: Determine the gravitational field strength at points P_1 , P_2 , and P_3 .

 <p>P_1 M_1 P_2 M_2 P_3</p> <p><i>Gravitational field strength</i> is a vector (it has a number and a direction) so we need to do all that “vector stuff.”</p> $\vec{g} = \frac{Gm_1}{r_1^2} + \frac{Gm_2}{r_2^2}$	<p>Let positive x be towards the right.</p> <p>At point 1 \vec{g} is pointing towards the right.</p> <p>At point 2 \vec{g} can point towards the left, can be zero, or can point towards the right.</p> <p>At point 3 \vec{g} is pointing towards the left.</p>
--	--

Example 2: Determine the gravitational field strength at point P.

 <p><i>Gravitational field strength</i> is a vector (it has a number and a direction) so we need to do all that “vector stuff.”</p>	<p>Draw an axis and determine the angles between point P and each of the four masses.</p> $g_x = \frac{Gm_1}{r_1^2} \cos \theta_1 + \frac{Gm_2}{r_2^2} \cos \theta_2 + \frac{Gm_3}{r_3^2} \cos \theta_3 + \frac{Gm_4}{r_4^2} \cos \theta_4$ $g_y = \frac{Gm_1}{r_1^2} \sin \theta_1 + \frac{Gm_2}{r_2^2} \sin \theta_2 + \frac{Gm_3}{r_3^2} \sin \theta_3 + \frac{Gm_4}{r_4^2} \sin \theta_4$ $ g = \sqrt{g_x^2 + g_y^2} \text{ (magnitude)}$ $\theta = \tan^{-1} \left \frac{g_y}{g_x} \right \text{ (direction)}$
--	--

2. **Review from 6.2:** List some rules for drawing *gravitational field lines*:
<https://www.miniphysics.com/gravitational-field-lines.html>
https://phymath.com/lecture_notes/Gravitation_online.pdf
 - a.
 - b.
 - c.
 - d.
 - e.
3. What is constant in a *gravitational equipotential surface*?
<https://pages.uncc.edu/phys2102/online-lectures/chapter-4-electric-potential/4-2-equipotential-surfaces/>
4. Draw a spherical planet with *gravitational field lines* and *equipotential surfaces*.
https://www.physics.brocku.ca/PPLATO/h-flap/phys3_1.html
5. How much work is done in moving a mass along the same *equipotential surface*?
6. How much work is done in moving a mass along two different *equipotential surfaces*? State the equation.
7. What is the relationship between an objects *gravitational equipotential surfaces* and *gravitational field lines*?

8. The following problem refers to *electrostatic field strength*. This is also called *electric field strength*.

https://cphysics.fandom.com/wiki/Electric_Field_strength

<https://www.physicsclassroom.com/class/estatics/Lesson-4/Electric-Field-Intensity>

- a. Define *electrostatic field strength*. Is it a scalar or a vector?

- b. What is the equation and what are the units for *electrostatic field strength*? Define each variable.

- c. Where is the *electrostatic field strength* zero? Where is the *electrostatic field strength* maximum?

- d. What are the mathematical limits of *electrostatic field strength*? Can *electrostatic field strength* be positive? Negative? Zero?

9. **Review from 5.1:** List some rules for *electrostatic field lines*:

<https://www.physicsclassroom.com/class/estatics/Lesson-4/Electric-Field-Lines>

<https://byjus.com/physics/electric-field-lines/>

10. What is an *electrostatic equipotential surface*?

<https://openstax.org/books/college-physics/pages/19-4-equipotential-lines>

<https://openstax.org/books/university-physics-volume-2/pages/7-5-equipotential-surfaces-and-conductors>

11. Draw a spherical negative charge and a spherical positive charge, both with equal magnitudes of charge and volume, with *electric field lines* and *equipotential surfaces*.

<https://openpress.usask.ca/physics155/chapter/3-5-equipotential-surfaces-and-conductors/>

12. Draw two spherical negative charges, both with equal magnitudes of charge and volume, with *electric field lines* and *equipotential surfaces*.

<https://openpress.usask.ca/physics155/chapter/3-5-equipotential-surfaces-and-conductors/>

13. How much work is done in moving a charge along the same *electric equipotential surface*?

14. How much work is done in moving a charge along a different *equipotential surface*? State the equation.

15. What is the relationship between an object's *electric equipotential surfaces* and *electric field lines*?

16. **Review from 5.1:** Draw *electric field lines* and *equipotential surfaces* between parallel plates with an equal and opposite charge. For parallel plates remember the equations $Fd = qV$ and $V = Ed$.

<https://www.physicscurriculum.com/electrostatics3d/>

Part 3: Watch and take notes on the following videos**IB Physics: Topic 10 Fields**

Chris Doner

https://www.youtube.com/watch?v=vq04MAcy5c8&list=PLPsx331rqafU-cxLZBYdH_3vK53bgepUh

Watch and take notes on all the videos in the playlist!

Name: _____

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10.2 Fields at Work

Understandings

- Potential and potential energy
- Potential gradient
- Potential difference
- Escape speed
- Orbital motion, orbital speed, and orbital energy
- Forces and inverse-square law behavior

Equations

$V_g = -\frac{GM}{r}$	$V_e = \frac{kQ}{r}$
$g = -\frac{\Delta V_g}{\Delta r}$	$E = -\frac{\Delta V_e}{\Delta r}$
$E_p = mV_g = -\frac{GMm}{r}$	$E_p = qV_e = \frac{kQq}{r}$
$F_g = \frac{GMm}{r^2}$	$F_e = \frac{kQq}{r^2}$

$$v_{esc} = \sqrt{\frac{2GM}{r}}$$

$$v_{orbit} = \sqrt{\frac{GM}{r}}$$

2. The following problem refers to *gravitational potential energy*.
<https://openstax.org/books/university-physics-volume-1/pages/13-3-gravitational-potential-energy-and-total-energy>
- a. Define *gravitational potential energy*. Is it a scalar or a vector?

 - b. What is the equation of the *gravitational potential energy* of an object when it is near the surface of a planet? What is the general equation of the *gravitational potential energy*? What is the significance of the negative sign? What are the units of *gravitational potential energy*?
3. The following problem refers to *gravitational force*.
<http://hyperphysics.phy-astr.gsu.edu/hbase/grav.html#grav>
- a. Define *gravitational force*. Is it a scalar or a vector?

 - b. What is the equation for the *gravitational force* on an object when it is near the surface of a planet? What is the general equation for the *gravitational force*? This is also called *Newton's Law of Gravitation*. What are the units of the *gravitational force*?

4. You might want to derive this equation with your teacher: A planet is orbiting in a circular motion with a constant speed around a star (like the Sun).
- a. Use Newton's Law of Gravitation $F_g = m_{planet} a_{planet} = \frac{Gm_{star}m_{planet}}{r^2}$ and the equation for centripetal acceleration $a_{planet} = \frac{v_{planet}^2}{r}$ to solve for the speed squared v_{planet}^2 of a planet moving around a star. Place a box around your answer. In both equations r is the distance from the planet to the star.
- b. Take your solution from part a and multiply both sides by $\frac{m_{planet}}{2}$. This new equation is equal to the kinetic energy of the planet. Place a box around your answer.
- c. Substitute your answer from part b to the total energy of the orbiting planet $E_{total} = KE + GPE = \frac{1}{2}m_{planet}v_{planet}^2 - \frac{Gm_{planet}m_{star}}{r}$. Place a box around your answer. Your answer should have only one fraction.

- d. Is the total energy positive, negative, or zero? Why?
- e. Draw a graph of energy vs. distance. On this graph draw the kinetic energy vs. distance, potential energy vs. distance, and total energy vs. distance.
<http://hyperphysics.phy-astr.gsu.edu/hbase/vesc.html#ves>
5. Define *escape velocity*. This is also called *escape speed*.
<http://hyperphysics.phy-astr.gsu.edu/hbase/vesc.html#ves>
6. What are some assumptions made when defining *escape velocity*?
7. For which objects does *escape velocity* apply to?
8. For which objects does *escape velocity* not apply to?

9. Use the law of conservation of energy $E_{initial} = E_{final}$ to solve for the equation of the *escape velocity* of an object leaving the gravitational pull of a planet. What is the minimum speed needed for an object to escape the gravitational pull of the Earth?
<http://hyperphysics.phy-astr.gsu.edu/hbase/vesc.html#ves>

10. The following problem refers to *electrostatic potential*. This is also called *electric potential*.
<https://openstax.org/books/physics/pages/18-4-electric-potential>

- a. Define *electrostatic potential*. Is it a scalar or a vector?
- b. What is the equation for *electrostatic potential*? What are the units of *electrostatic potential*?

11. The following problem refers to *electrostatic potential energy*. This is also called *electric potential energy*.
<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elepe.html>

- a. Define *electrostatic potential energy*. Is it a scalar or a vector?
- b. What is the equation for *electrostatic potential energy*? What are the units for *electrostatic potential energy*?

12. The following problem refers to the *electrostatic force*. This is also called *Coulomb's Law*.

<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elefor.html#c1>

a. Define the *electrostatic force*. Is it a scalar or a vector?

Please review the 5.1 video!

b. What is the equation for the *electrostatic force*? What are the units for the *electrostatic force*?

Name: _____

Class: _____

Due Date: _____

11.1 Electromagnetic Induction

Understandings

- Electromotive force (emf)
- Magnetic flux and magnetic flux linkage
- Faraday's law of induction
- Lenz's law

Equations

$$\phi = BA \cos \theta$$

$$\varepsilon = -N \frac{\Delta \phi}{\Delta t}$$

$$\varepsilon = Bvl$$

$$\varepsilon = Bvln$$

Part 1: Review section 5.4**Part 2: Use your favorite sources to answer the following questions****The solutions can be found on the YouTube channel Go Physics Go:**

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

1. Define *induction* and *induce*.

<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/induct.html>
www.dictionary.com

2. What are the units of *electromotive force EMF*?

<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/induct.html>
<http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/indcur.html#c2>

3. True or false: *Electromotive force EMF* is a force.

4. Define *flux*. Draw a picture.

www.dictionary.com

5. *Magnetic flux* is defined as $\Phi = BA \cos \theta$. Define and give the units of each variable. Draw an image showing *magnetic flux* and label theta θ in the image. Also draw an image of magnetic flux when $\theta = 0^\circ$ and when $\theta = 90^\circ$.

<http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/fluxmg.html#c1>

6. Define *magnetic flux linkage*. Equation? Units?

7. Use words to define and describe Faraday's Law $\varepsilon = -N \frac{\Delta\Phi}{\Delta t}$. Draw a picture if you have to.

<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/farlaw.html#c1>

8. The negative sign in Faraday's Law is known as Lenz's Law. What does it mean?

<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/farlaw.html#c1>

See part 3 in this section for examples.

9. What happens to a magnet if it falls down a hollow metal cylinder? Why?

<https://www.youtube.com/watch?v=N7tli71-AjA>

Part 3: Use Lenz's law and the right hand rule to determine the direction of the induced current on the metal conducting wire.

$$\varepsilon = -\frac{d\phi}{dt} = -\frac{d}{dt}[NBA \cos \theta] = -N \frac{d}{dt}[BA \cos \theta]$$

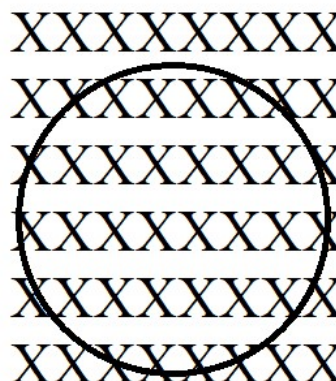
<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/farlaw.html>

<https://openstax.org/books/university-physics-volume-2/pages/13-2-lenzs-law>

<https://www.youtube.com/watch?v=mqZR3F4QA1s>

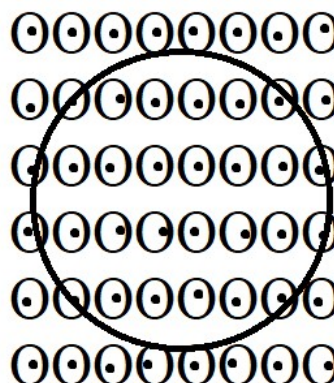
1. There is a magnetic field which points into the page. The magnitude of the magnetic field is

- decreasing.
- constant.
- increasing.

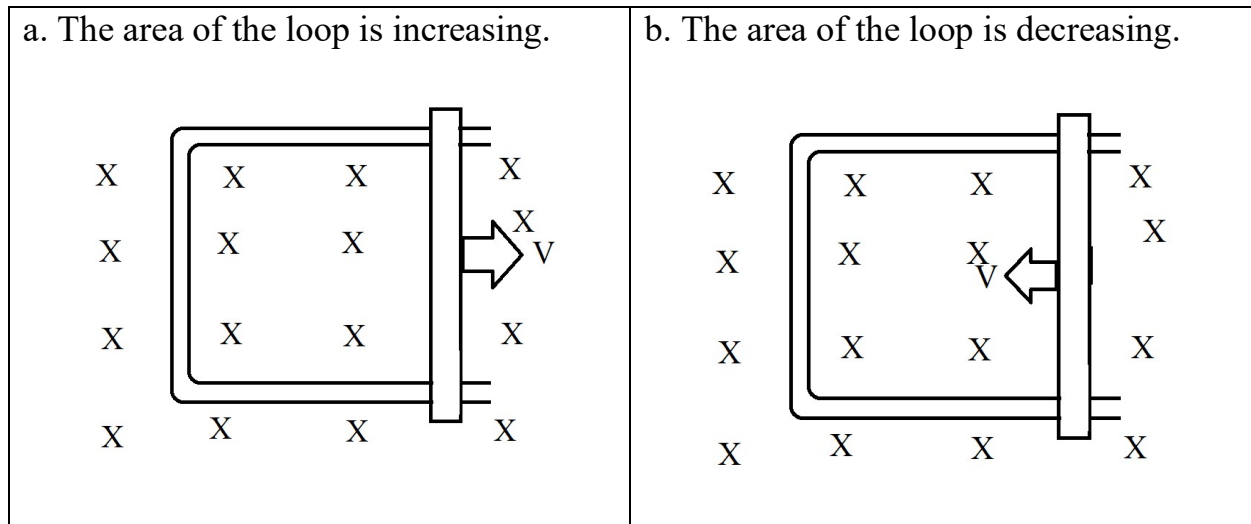


2. There is a magnetic field which points out the page. The magnitude of the magnetic field is

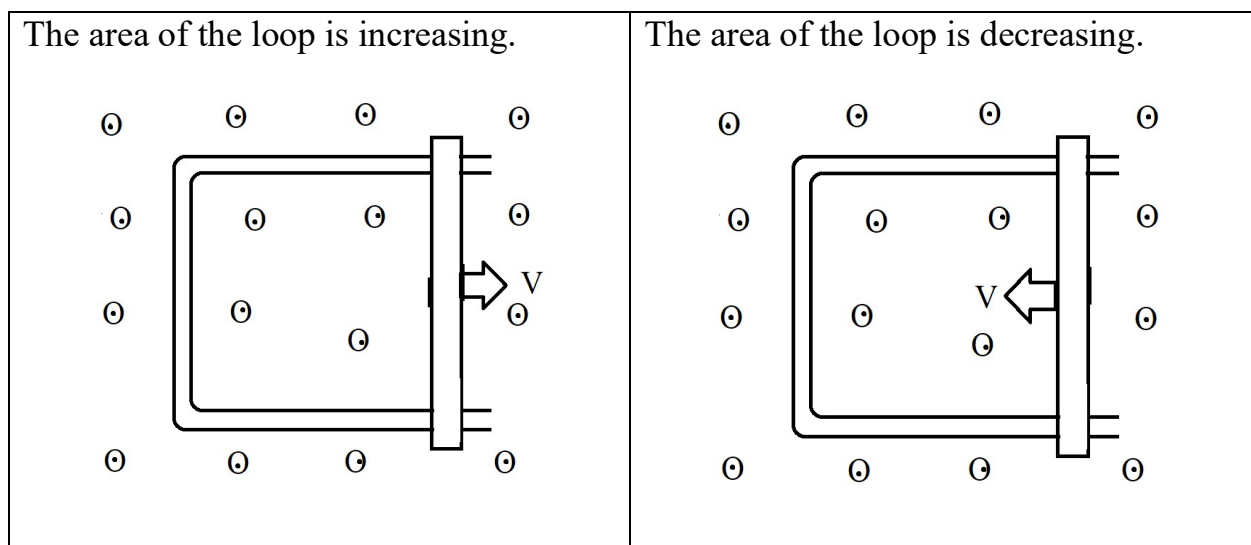
- decreasing.
- constant.
- increasing.



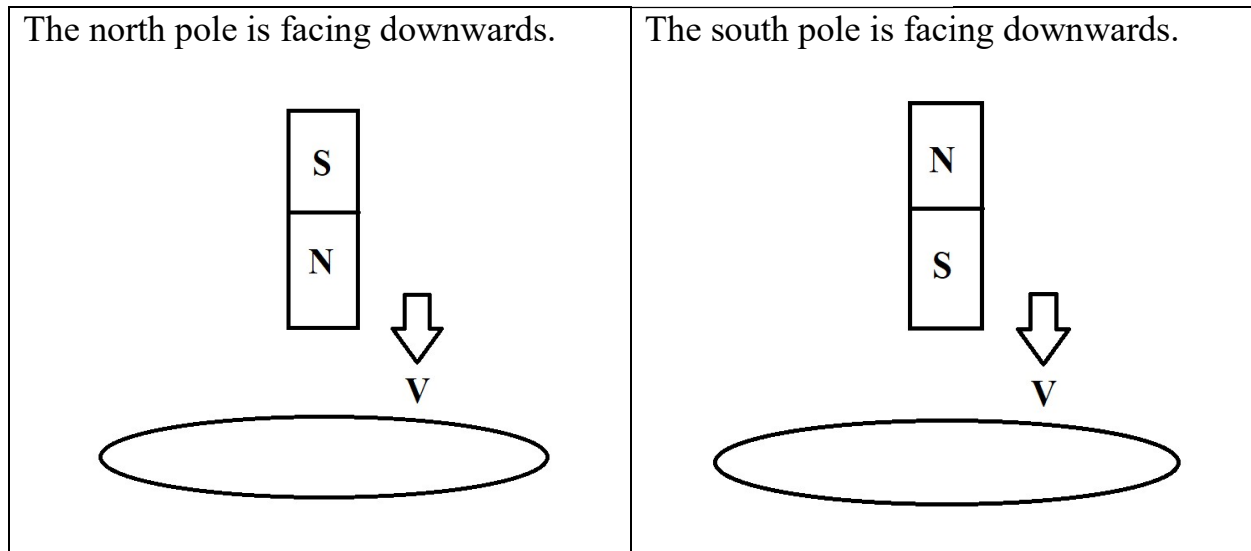
3. There is a constant magnetic field into the page. Which direction is the induced current?



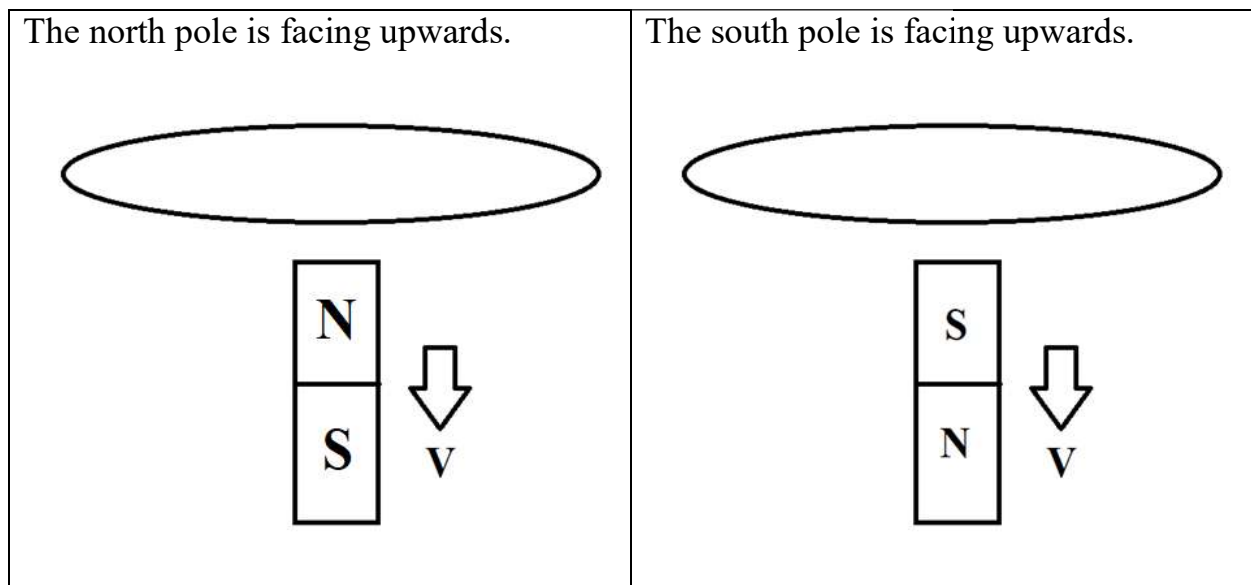
4. There is a constant magnetic field out of the page.



5. A magnet is falling down and entering a loop. Which direction is the induced current if we are looking downwards?

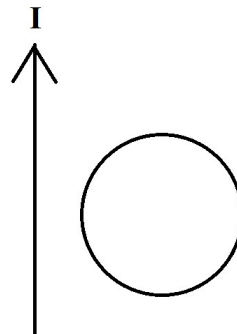


6. A magnet is falling down and leaving a loop. Which direction is the induced current if we are looking downwards?



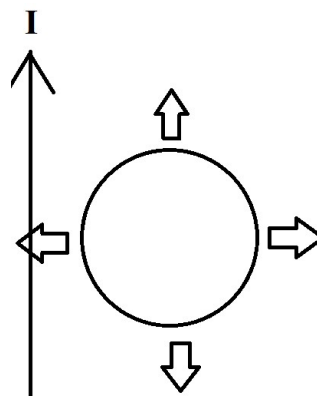
7. There is a current carrying straight wire. There is a circular wire next to it. The current in the straight wire is

- a. decreasing.
- b. constant.
- c. increasing.



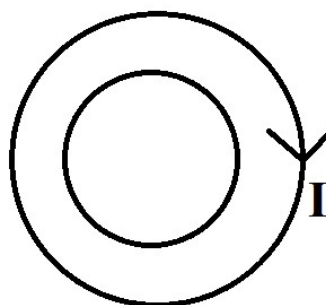
8. There is a current carrying straight wire. There is a circular wire next to it. The circular wire

- a. moves up parallel to the wire.
- b. moves down parallel to the wire.
- c. moves to the left perpendicular to the wire.
- d. moves to the right perpendicular to the wire.



9. A small loop of wire is inside a larger loop of wire. The larger loop of wire has a constant current clockwise. What is the direction of the induced current of the smaller loop if the current of the larger loop is

- a. decreasing.
- b. constant.
- c. increasing.



Part 4: Watch and take notes on the following videos

Physics 45 Electromagnetic Induction: Faraday's Law and Lenz's Law (1 of 2)

Introduction

Michel Van Biezen

https://www.youtube.com/watch?v=1-aoGz5X_j0

Physics 45 Electromagnetic Induction: Faraday's Law (1 of 4) An Intro and Understanding

Michel Van Biezen

<https://www.youtube.com/watch?v=ejRJM-kCyWQ>

IB Physics - 11.1.1 - Flux, flux density and flux linkage

LovattPhysics

<https://www.youtube.com/watch?v=UdoZXi80zFg>

Induced emf & Faraday's Law - A-level Physics

Science Shorts

<https://www.youtube.com/watch?v=4ghP5peCft8>

Name: _____

Class: _____

Due Date: _____

11.2 Transmission of Power

Understandings

- Alternating current (ac) generators
- Average power and root mean square (rms) values of current and voltage
- Transformers
- Diode bridges
- Half-wave and full-wave rectification

Equations

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$R = \frac{V_0}{I_0} = \frac{V_{rms}}{I_{rms}}$$

$$P_{max} = I_0 V_0$$

$$\bar{P} = \frac{1}{2} I_0 V_0$$

$$\frac{\varepsilon_p}{\varepsilon_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}$$

Part 1: Use your favorite sources to answer the following questions

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

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

1. What is the meaning of *DC*? What are its units? Draw a *DC vs. time* graph.
<https://openstax.org/books/college-physics/pages/20-5-alternating-current-versus-direct-current>
2. Where do we see *DC* being used?
3. What is the meaning of *AC*? What are its units? Draw an *AC vs. time* graph.
4. Where do we see *AC* being used?
5. Which is more widely generated in a power plant: *AC* or *DC*?

6. Give a brief list/summary of how AC is created. Draw and label an image.
7. Is magnetic flux in phase or out of phase with the induced emf? What about the induced current with the emf?
<https://openstax.org/books/university-physics-volume-2/pages/15-2-simple-ac-circuits>
8. What is the benefit of slip rings and carbon brushes?
<https://www.electrical4u.com/slip-ring/>
<https://www.renown-electric.com/blog/how-it-works-carbon-brush-operation/>
9. What is the benefit of determining the root mean square of a function as opposed to the average of a function?
<https://openstax.org/books/university-physics-volume-2/pages/15-2-simple-ac-circuits>
https://www.youtube.com/watch?v=os_X6Ej6lgw

10. The equation for voltage in an AC circuit is given as $V_{rms} = \frac{V_0}{\sqrt{2}}$. The equation for current in an AC circuit is $I_{rms} = \frac{I_0}{\sqrt{2}}$. Define the variables in the equations. State all the equations related to root mean square from the physics data booklet.

<https://www.youtube.com/watch?v=FrRmihdF52o>

11. Draw an *emf vs. time* graph of a conducting loop rotating in the presence of an external magnetic field with a frequency of f and $2f$.

12. What does a transformer do? Draw a symbol of a transformer.

<http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/transf.html#c1>

13. How is current induced in a transformer? In other words, how does current transfer from the primary coil to the secondary coil?

14. Is a transformer used for alternating current, direct current, or both?
15. Circle the correct choices in italic font: The power in a step-up transformer *decreases/increases/stays the same*. The number of secondary loops in a step-up transformer is *less/more* than the number of primary loops. A step-up transformer *decreases/increases* the current while *decreasing/increasing* the voltage through a wire. The frequency of the secondary coil in a step-up transformer is *less than/greater than/equal to* the frequency of the primary coil.
16. **Use a pencil!** Draw a step-up transformer. Draw arrows to show the direction of the current.
<https://openstax.org/books/college-physics/pages/23-7-transformers>
17. Circle the correct choices in italic font: The power in a step-down transformer *decreases/increases/stays the same*. The number of secondary loops in a step-down transformer is *less/more* than the number of primary loops. A step-down transformer *decreases/increases* the current while *decreasing/increasing* the voltage through a wire. The frequency of the secondary coil in a step-down transformer is *less than/greater than/equal to* the frequency of the primary coil.
18. **Use a pencil!** Draw a step-down transformer. Draw arrows to show the direction of the current.

19. State the equation from the IB Physics Data Booklet for a transformer which relates the primary voltage to the secondary voltage, the primary current to the secondary current, and the primary number of loops to the secondary number of loops.
20. Describe the following effects in a non-ideal transformer:
- a. Flux leakage:
<https://www.electrical4u.com/resistance-leakage-reactance-or-impedance-of-transformer/>

 - b. Joule heating:
<https://electronicsreference.com/module4/transformers/>

 - c. Eddy currents:
<https://www.electrical4u.com/eddy-currents-theory-and-applications/>
<https://www.electrical4u.com/eddy-current-losses-transformer-occur/>

 - d. Magnetic hysteresis:
<https://circuitglobe.com/what-is-a-magnetic-hysteresis.html>
<https://resources.pcb.cadence.com/blog/2020-hysteresis-loss-in-a-transformer-and-how-it-affects-ac-circuits>
<https://electricalengineering123.com/explanation-of-hysteresis-loss-eddy-current-losses-in-transformers/>

21. Where are you most likely to find a step-up transformer? Why?
22. Where are you most likely to find a step-down transformer? Why?
23. Why is the voltage through a wire from the power plant to a neighborhood so high?
24. **Use a pencil!** What does a diode do? Draw the symbol of a diode.
<https://openstax.org/books/university-physics-volume-2/pages/9-4-ohms-law>
25. **Use a pencil!** Draw a current vs. time graph for half wave rectification.
26. **Use a pencil!** What is a diode bridge rectifier? What does it do? Draw it.
<http://hyperphysics.phy-astr.gsu.edu/hbase/Electronic/rectbr.html>

27. **Use a pencil!** Draw a current vs. time graph for full wave rectification.
<https://www.electrical4u.com/bridge-rectifiers/>

Part 2: Watch and take notes on the following videos

Alternating current (ac) generators

AC Electrical Generator Basics - How electricity is generated

The Engineering Mindset

<https://www.youtube.com/watch?v=WhATjUHgzxQ>

GCSE Science Revision Physics "The Alternator and Dynamo" (Triple)

Freesciencelessons

<https://www.youtube.com/watch?v=k1iivkRjd1U>

Electric Generators, Induced EMF, Electromagnetic Induction - Physics

The Organic Chemistry Tutor

<https://www.youtube.com/watch?v=-QJS6i1bhG4>

Average power and root mean square (rms) values of current and voltage

Root Mean Square (RMS) Value of a Sine Wave

katkimshow

https://www.youtube.com/watch?v=os_X6Ej6l1gw

Intro to AC Circuits using Phasors and RMS Voltage and Current | Doc Physics

Doc Schuster

<https://www.youtube.com/watch?v=FrRmihdF52o>

Transformers

Transformers - Electric Power transmission

Physics Videos by Eugene Khutoryansky

<https://www.youtube.com/watch?v=agujzHdvtjc>

**Transformers Physics Problems - Voltage, Current & Power Calculations -
Electromagnetic Induction**

The Organic Chemistry Tutor

<https://www.youtube.com/watch?v=GJm-FOMeG4E>

Diode bridges

Half-wave and full-wave rectification

Full Wave Bridge Rectifiers

The Organic Chemistry Tutor

<https://www.youtube.com/watch?v=EkHch86UXpY>

Full wave rectification and diode bridge [IB Physics HL]

OSC

<https://www.youtube.com/watch?v=Y8qjpiNJuf0>

Basic AC-DC Converter Using Four Diodes

katkimshow

<https://www.youtube.com/watch?v=Zn0GisHgWY4>

Name: _____

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Due Date: _____

11.3 Capacitance

Understandings

- Capacitance
- Dielectric materials
- Capacitors in series and parallel
- Resistor-capacitor (RC) series circuits
- Time constant

Equations

$$C = \frac{q}{V}$$

$$C_{parallel} = C_1 + C_2 + \dots$$

$$\frac{1}{C_{series}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

$$C = \epsilon \frac{A}{d}$$

$$E = \frac{1}{2} CV^2$$

$$\tau = RC$$

$$q = q_0 e^{-\frac{t}{\tau}}$$

$$I = I_0 e^{-\frac{t}{\tau}}$$

$$V = V_0 e^{-\frac{t}{\tau}}$$

Part 1: Use your favorite sources to answer the following questions

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

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

1. **Use a pencil!** What is a capacitor? What are its uses? Draw the symbol of a capacitor.

<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/capac.html#c1>

2. What is the meaning of capacitance? Equation? Units?

<https://openstax.org/books/university-physics-volume-2/pages/8-1-capacitors-and-capacitance>

3. State the equation and define each variable which gives the capacitance of a parallel plate capacitor to its physical dimensions.

<https://openstax.org/books/university-physics-volume-2/pages/8-1-capacitors-and-capacitance>

4. What is a dielectric? What does a dielectric do to the capacitance when it is put inside a capacitor?
<https://openstax.org/books/university-physics-volume-2/pages/8-4-capacitor-with-a-dielectric>

5. **Use a pencil!** Draw three capacitors in parallel and state the equation when simplifying capacitors in parallel.

6. Circle the correct choice in italic font: Connecting capacitors in parallel leads to a *larger/smaller* capacitance.

7. **Use a pencil!** Draw three capacitors in series and state the equation when simplifying capacitors in series.

8. Circle the correct choice in italic font: Connecting capacitors in series leads to a *larger/smaller* capacitance.

9. Capacitors in parallel have the same **potential difference/voltage** while capacitors in series have the same **charge**.

10. What are some equations for the energy stored in a capacitor?

<https://openstax.org/books/university-physics-volume-2/pages/8-3-energy-stored-in-a-capacitor>

<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/capeng.html#c1>

11. **Use a pencil!**

- a. Draw a circuit which shows a capacitor **charging**. The circuit should contain a battery, resistor, capacitor, and wires.

- b. Draw three graphs of voltage vs. time, charge vs. time, and current vs. time when **charging** a capacitor. Label and give the equations of the graphs.
<http://hyperphysics.phy-astr.gsu.edu/hbase/electric/capchg.html>

- c. Draw a circuit which shows a capacitor **discharging**. The circuit should contain a battery, resistor, capacitor, and wires.

- d. Draw three graphs of voltage vs. time, charge vs. time, and current vs. time when **discharging** a capacitor. Label and give the equations of the graphs.
<http://www.hyperphysics.de/hyperphysics/hbase/electric/capdis.html>

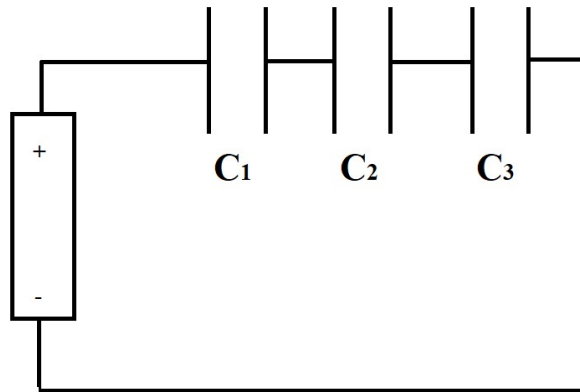
12. What is the equation for the *time constant* τ ? What are the units of the time constant? What does it tell us?
<https://openstax.org/books/university-physics-volume-2/pages/10-5-rc-circuits>

13. What is the benefit of adding a capacitor in parallel with the diode bridge and resistor from section 11.2?

<https://www.electrical4u.com/diode-bridge-rectifier/>

Part 2: Circuits

1.



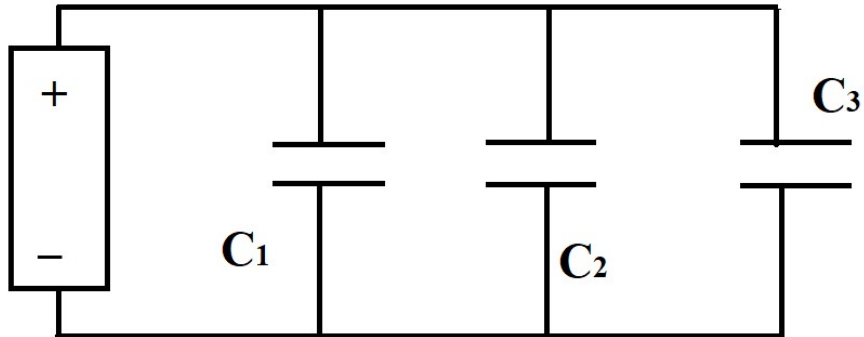
Given:

$V_{\text{Battery}} = 10 \text{ V}$	$C_1 = 1 \text{ F}$	$C_2 = 2 \text{ F}$	$C_3 = 3 \text{ F}$
-------------------------------------	---------------------	---------------------	---------------------

Solve for the unknowns. Fractions only.

$C_{\text{equivalent}}$	Q_1	V_1
	Q_2	V_2
	Q_3	V_3

2.



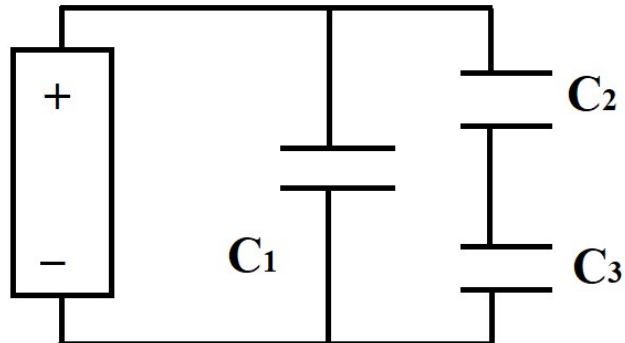
Given:

$V_{\text{Battery}} = 10 \text{ V}$	$C_1 = 1 \text{ F}$	$C_2 = 2 \text{ F}$	$C_3 = 3 \text{ F}$
-------------------------------------	---------------------	---------------------	---------------------

Solve for the unknowns. Fractions only.

$C_{\text{equivalent}}$	Q_1	V_1
	Q_2	V_2
	Q_3	V_3

3.



Given:

$V_{\text{Battery}} = 10 \text{ V}$	$C_1 = 1 \text{ F}$	$C_2 = 2 \text{ F}$	$C_3 = 3 \text{ F}$
-------------------------------------	---------------------	---------------------	---------------------

Solve for the unknowns. Fractions only.

$C_{\text{equivalent}}$	Q_1	V_1
	Q_2	V_2
	Q_3	V_3

Part 3: Watch and take notes on the following videos

Capacitance
Dielectric materials
Capacitors in series and parallel
Resistor-capacitor (RC) series circuits
Time constant

Capacitors in Series and Parallel

Physics Videos by Eugene Khutoryansky
<https://www.youtube.com/watch?v=BIPi0vXdssE>

Capacitors and Capacitance: Capacitor physics and circuit operation

Physics Videos by Eugene Khutoryansky
https://www.youtube.com/watch?v=f_MZNsEqyQw

How a capacitor works: from fizzics.org

Fizzics Organization
<https://www.youtube.com/watch?v=W7vY3ldfwP0>

Capacitors Explained - The basics how capacitors work working principle

The Engineering Mindset
<https://www.youtube.com/watch?v=X4EUwTwZ110>

Capacitors work like this: from fizzics.org

Fizzics Organization
<https://www.youtube.com/watch?v=DoK-JmfMPCo>

Capacitors - Basic Introduction - Physics

The Organic Chemistry Tutor
<https://www.youtube.com/watch?v=BimpNou0orc>

IB Physics - 11.2.3 - Converting AC to DC

LovattPhysics
<https://www.youtube.com/watch?v=sjZqBbdbOcU>

Farads measuring capacitance: from fizzics org

Fizzics Organisation
<https://www.youtube.com/watch?v=W0tW5LzZQ0o>

Capacitor charge time calculation - time constants

The Engineering Mindset

<https://www.youtube.com/watch?v=FDmHVRC6pQk>**RC Circuits Physics Problems, Time Constant Explained, Capacitor Charging and Discharging**

The Organic Chemistry Tutor

<https://www.youtube.com/watch?v=PLQrPqYlPmI>**Basic AC-DC Converter Using Four Diodes**

katkimshow

<https://www.youtube.com/watch?v=Zn0GisHgWY4>

Name: _____

Class: _____

Due Date: _____

12.1 The Interaction of Matter with Radiation

Understandings

- Photons
- The photoelectric effect
- Matter waves
- Pair production and pair annihilation
- Quantization of angular momentum in the Bohr model for hydrogen
- The wave function
- The uncertainty principle for energy and time and position and momentum
- Tunneling, potential barrier and factors affecting tunneling probability

Equations

$$E = hf$$

$$E_{max} = hf - \phi$$

$$E = -\frac{13.6}{n^2} eV$$

$$mvr = \frac{nh}{2\pi}$$

$$P(r) = |\Psi|^2 \Delta V$$

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

If you are interested in learning more about quantum and nuclear physics then please read the book *The Quantum Story: A History in 40 Moments* by Jim Baggott.

If you are interested in learning more about quantum and nuclear physics then please watch all the videos from this website:

<https://www.learner.org/series/physics-for-the-21st-century/>

Photons

<http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/expar.html#c5>

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

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

1. Fill in the blanks from the table below: Electromagnetic waves, which contain _____, come in small amounts/bundles called quanta/quantum or _____. Light is an _____. From chapter 4 we concluded that light behaves as a wave. The _____ (chapter 12) tells us that light behaves as a particle! An _____ moving around the nucleus of an atom _____ and _____ photons. If we slowed down a video recording of a light bulb then we would see “flashes of light” as opposed to a _____ emission of light.

energy	photoelectric effect	emits
photons	electron	continuous
electromagnetic wave	absorbs	

Equations for photons:

$$E = hf$$

$$v = \lambda/T = \lambda f$$

In general: $E^2 = p^2c^2 + m^2c^4$

For photons: $E = pc = hf \rightarrow p = hf/c = h(f/c) = h/\lambda$

The Photoelectric Effect

<http://hyperphysics.phy-astr.gsu.edu/hbase/mod1.html#c2>

<http://hyperphysics.phy-astr.gsu.edu/hbase/mod2.html#c3>

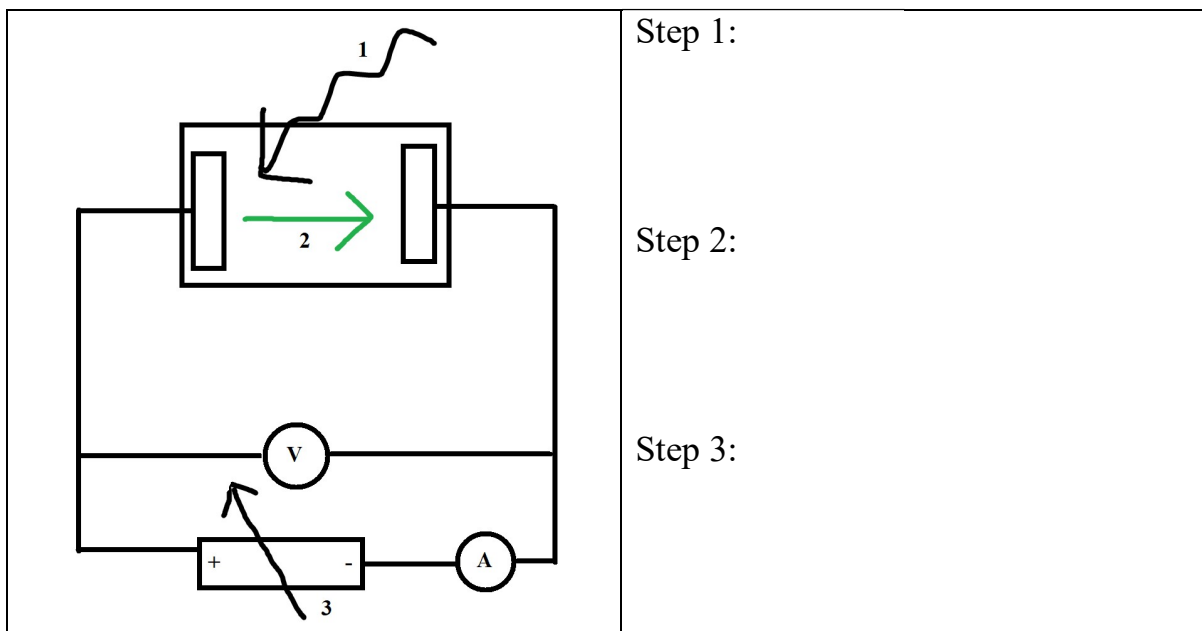
The solutions can be found on the YouTube channel Go Physics Go:

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

1. Briefly describe the *photoelectric effect*.
2. About how long does it take for the electrons to leave the metal during the photoelectric effect?
3. Define *critical/threshold frequency*.
4. What will happen to the metal if the intensity of the electromagnetic wave is increased while it is still below the *critical/threshold frequency*? Will the photoelectric effect occur?
5. What will happen to the electrons if the intensity of the electromagnetic wave is increased while it is above the *critical/threshold frequency*?
6. What is the *work function* φ ?
7. Describe the equation given in the physics data booklet: $E_{max} = hf - \varphi$.
8. Draw an E_{max} vs. incoming frequency graph for three metals. What does the

horizontal and vertical intercepts tell us? What does the slope tell us?

9. Describe, step by step, what is happening in the lab setup below.



10. Define *stopping potential/voltage*.

11. From the lab setup from question 9 draw a graph of the *current vs. potential difference across the anode and cathode* with the same incoming frequencies and different intensities.

12. From the lab setup from question 9 draw a graph of the *current vs. potential difference across the anode and cathode* with different incoming frequencies.

13. What is the meaning of *energy is quantized*?

14. State two experiments in which light behaves as a wave. Do not explain the experiments, just state them.

15. State an experiment in which light behaves as a particle. Do not explain the experiment, just state it.

Matter Waves

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

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

1. What is the de Broglie hypothesis? What is the equation?
<http://hyperphysics.phy-astr.gsu.edu/hbase/debrog.html#c3>
2. Usain Bolt has a mass of 94 kg. He is running with a speed of 9.58 m/s. What is his wavelength?
3. An electron, which has a mass of 9.11×10^{-31} kg, is traveling with a speed of 9.58 m/s. What is its wavelength?
4. Where can we see particles, such as electrons, diffract? In which experiment do electrons diffract?
<https://physlab.org/class-demo/electron-diffraction/>
5. What is the meaning of wave-particle duality?
<http://hyperphysics.phy-astr.gsu.edu/hbase/mod1.html>

Pair Production and Pair Annihilation

<https://alevelphysics.co.uk/notes/particle-antiparticle-photons/>

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

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

1. Review section 7.3.
2. What is the difference between a particle and its antiparticle?
3. Complete the following table:

Particle	Antiparticle
Proton (2 up quarks, 1 down quark) uud	
Neutron (1 up quark, 2 down quarks) udd	
Electron	
Photon	
Neutrino	

4. What is the meaning of pair production? Give an example and draw a Feynman diagram of it.

<https://www.quantumdiaries.org/tag/feynman-diagrams/>

5. What is the meaning of pair annihilation? Give an example and draw a Feynman diagram of it.

<https://en.wikipedia.org/wiki/Annihilation>

Quantization of Angular Momentum in the Bohr Model for Hydrogen

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

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

1. You might want to derive this equation with your teacher: Use Newton's second law of motion, the equation for total energy, the equation for angular momentum $\vec{L} = r \times \vec{p}$, and the assumption that the angular momentum of an electron orbiting a hydrogen atom is quantized: $mvr = n(h/2\pi)$ to derive the equation for the energy of an electron orbiting a hydrogen atom is $E_{electron} \approx -13.6/n^2 \text{ eV}$.

<https://openstax.org/books/university-physics-volume-3/pages/6-4-bohrs-model-of-the-hydrogen-atom>

2. What is the meaning of the equation $E = -13.6 \text{ eV}/n^2$?

3. Describe the *Bohr model of the atom*.

<https://openstax.org/books/university-physics-volume-3/pages/6-4-bohrs-model-of-the-hydrogen-atom>

The Wave Function

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

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

1. What is the *wave function* $\Psi(x, t)$? Units? What does the *wave function* $\Psi(x, t)$ tell us? What does the square of the *wave function* $|\Psi(x, t)|^2$ tell us? What does the equation $P(r) = |\Psi|^2 \Delta V$ tell us?
<http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/wvfun.html#c1>
<http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/qm.html#c4>
<https://openstax.org/books/university-physics-volume-3/pages/7-1-wave-functions>

2. Draw a Ψ vs. x graph which shows a large uncertainty in momentum and a small uncertainty in position.

3. Draw a Ψ vs. x graph which shows a small uncertainty in momentum and a large uncertainty in position.

4. Define *quantum mechanics*.
www.dictionary.com

5. What is the *Copenhagen interpretation*?

The Uncertainty Principle for Energy and Time & Position and Momentum

<http://hyperphysics.phy-astr.gsu.edu/hbase/uncer.html#c1>

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

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

1. What does the *Heisenberg Uncertainty Principle* tell us?
<https://openstax.org/books/university-physics-volume-3/pages/7-2-the-heisenberg-uncertainty-principle>
2. What is the equation for the *position-momentum uncertainty principle*?
3. Usain Bolt has a mass of 94 kg. He is running with a speed of 9.58 m/s. What is the uncertainty in his position if the uncertainty in his momentum is 0.05%?
4. What is the equation for the *energy-time uncertainty principle*?
5. Is this uncertainty caused by bad measuring instruments?

Tunneling, Potential Barrier, and Factors Affecting Tunneling Probability

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

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

1. What is the meaning of quantum tunneling?
<https://www.secretsofuniverse.in/quantum-tunneling/>
<http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/barr.html>
<https://openstax.org/books/university-physics-volume-3/pages/7-6-the-quantum-tunneling-of-particles-through-potential-barriers>
2. Which factors does tunneling depend on?
3. Give some real life examples of quantum tunneling. Where does it occur?

Part 2: Watch and take notes on the following videos

Photons

The photoelectric effect

Matter waves

Pair production and pair annihilation

Quantization of angular momentum in the Bohr model for hydrogen

The wave function

The uncertainty principle for energy and time and position and momentum

Tunneling, potential barrier and factors affecting tunneling probability

Physics - Chapt. 66 Quantum Mechanics (5 of 9) Einstein - The Photoelectric Effect

Michel van Biezen

<http://www.ilectureonline.com/lectures/subject/PHYSICS/11/206/2235>

Name: _____

Class: _____

Due Date: _____

12.2 Nuclear Physics

Understandings

- Rutherford scattering and nuclear radius
- Nuclear energy levels
- The neutrino
- The law of radioactive decay and the decay constant

Equations

$$R = R_0 A^{1/3}$$

$$N = N_0 e^{-\lambda t}$$

$$A = \lambda N_0 e^{-\lambda t}$$

$$\sin \theta \approx \frac{\lambda}{D}$$

Rutherford Scattering and Nuclear Radius

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

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

1. Describe Rutherford scattering. Draw an image if you have to.
<http://hyperphysics.phy-astr.gsu.edu/hbase/rutsca.html>
<http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/rutsca2.html>
<http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/rutsca3.html>
2. What happens if fast moving electrons strike a thin gold foil?
3. Give the meaning of the equation $R = R_0 A^{1/3}$ and define each variable.
<http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/nucuni.html>
4. What is the meaning of *nuclear density*? What is the value of the *nuclear density*?
<https://www.thermal-engineering.org/what-is-density-of-nuclear-matter-nuclear-density-definition/>

Nuclear Energy Levels

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

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

1. Circle the correct answer: Alpha particles leave the nucleus with *continuous/discrete* energy levels.
2. Circle the correct answer: Beta minus particles leave the nucleus with *continuous/discrete* energy levels.
3. Circle the correct answer: Beta plus particles leave the nucleus with *continuous/discrete* energy levels.
4. Circle the correct answer: Gamma rays leave the nucleus with *continuous/discrete* energy levels.

The Neutrino

<http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/neutrino.html#c1>

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

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

1. Review section 7.1 and section 7.3.
2. Why was the neutrino postulated?

3. What is the charge and mass of an electron? What is the charge and mass of a neutrino?
<https://neutrinos.fnal.gov/mysteries/mass/>
<https://neutrino-science.com/what-is-the-mass-of-a-neutrino/>
<https://news.mit.edu/2021/new-upper-limit-mass-neutrinos-0214>

The Law of Radioactive Decay and the Decay Constant

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

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

1. Review section 7.1.
2. What is the meaning and what are the units of half-life $t_{1/2}$?
<https://openstax.org/books/university-physics-volume-3/pages/10-3-radioactive-decay>
<http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/halfli2.html>
3. What is the meaning and units of the *decay constant* λ ?
4. What is the meaning and units for *activity* A ? Describe and define the variables in the equation $A(t) = \lambda N_0 e^{-\lambda t}$.
5. Describe and define the variables in the equation $N(t) = N_0 e^{-\lambda t}$.

Part 2: Watch and take notes on the following videos**Neutrinos - Sixty Symbols**

Sixty Symbols

<https://www.youtube.com/watch?v=md1CKUQp04Q>**Neutrinos and the 2015 Nobel Prize in Physics - Sixty Symbols**

Sixty Symbols

<https://www.youtube.com/watch?v=XQHw7qQrpf0>**Neutrinos faster than light - Sixty Symbols**

Sixty Symbols

<https://www.youtube.com/watch?v=qJ0m13iJw0k>**Finding Neutrinos - Sixty Symbols**

Sixty Symbols

<https://www.youtube.com/watch?v=vbajL8kvue0>**Neutrinos slower than light - Sixty Symbols**

Sixty Symbols

<https://www.youtube.com/watch?v=cezltcn9Mv0>