Name: ________________________

Class: ________________________

Due Date: ________________________

B1 Rotational Dynamics

Understandings

- Torque
  http://hyperphysics.phy-astr.gsu.edu/hbase/torq.html#torq
  https://openstax.org/books/university-physics-volume-1/pages/10-6-torque
- Moment of inertia
  http://hyperphysics.phy-astr.gsu.edu/hbase/mi.html#mi
  https://openstax.org/books/university-physics-volume-1/pages/10-4-moment-of-inertia-and-rotational-kinetic-energy
- Rotational and translational equilibrium
  http://hyperphysics.phy-astr.gsu.edu/hbase/torq.html#equi
- Angular acceleration
  http://hyperphysics.phy-astr.gsu.edu/hbase/rotq.html#rq
  https://openstax.org/books/university-physics-volume-1/pages/10-1-rotational-variables
- Equations of rotational motion for uniform angular acceleration
  http://hyperphysics.phy-astr.gsu.edu/hbase/rotq.html#rq
  http://hyperphysics.phy-astr.gsu.edu/hbase/mi.html#mi
- Newton’s second law applied to angular motion
  http://hyperphysics.phy-astr.gsu.edu/hbase/mi.html#c2
- Conservation of angular momentum
  http://hyperphysics.phy-astr.gsu.edu/hbase/conser.html#conamo
  https://openstax.org/books/university-physics-volume-1/pages/11-2-angular-momentum

Equations

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

$360° = 2\pi\ radians$

$\vec{s} = [m] \rightarrow \theta = [rad]$

$\vec{v} = \left[\frac{m}{s}\right] \rightarrow \omega = [rad/sec]$

$\vec{a} = \left[\frac{m}{s^2}\right] \rightarrow \alpha = [rad/sec^2]$

$\omega = 2\pi f$

$v_f = at + v_i \rightarrow \omega_f = \alpha t + \omega_i$

${v_f}^2 - {v_i}^2 = 2a(x_f - x_i) \rightarrow {\omega_f}^2 - {\omega_i}^2 = 2\alpha(\theta_f - \theta_i)$

$x_f = \frac{1}{2}at^2 + v_i t + x_i \rightarrow \theta_f = \frac{1}{2}\alpha t^2 + \omega_i t + \theta_i$

$\vec{F}orce = m\vec{a} = [N] \rightarrow \vec{\tau} = \vec{r} \times \vec{F} = \vec{r}\vec{F}\sin\theta = [N \times m]$

$mass = [kg] \rightarrow I = moment\ of\ inertia = \sum mr^2 = [kg \times m^2]$

$KE_{translational} = \frac{1}{2}mv^2 \rightarrow KE_{rotational} = \frac{1}{2}I\omega^2$

$KE_{translational} = \frac{1}{2}mv^2 \rightarrow KE_{translational} + KE_{rotational} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$\sum \vec{F} = m\vec{a} = [N] \rightarrow \sum \vec{\tau} = \sum\left(\vec{r}\vec{F}\sin\theta\right) = I\alpha = [N]$

$W = \vec{F}\vec{d}\cos\theta = [N] \rightarrow W = \tau\theta = [N]$

$Power = \vec{F}\vec{v} = [Watts] \rightarrow Power = \tau\omega = [Watts]$

$\vec{p} = m\vec{v} \rightarrow L = I\omega$

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

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

Part 1: Review topic 2 (mechanics) and topic 6 (circular motion and gravitation)

Part 2: Answer the following questions

1. Define, state the equation, and give the units of *angular position* θ.
   https://openstax.org/books/university-physics-volume-1/pages/10-1-rotational-variables

2. Define, state the equation, and give the units of *angular speed* ω.

3. Define, state the equation, and give the units of *angular acceleration* α.

4. Convert the suvat equations from linear motion to circular motion.

5. Define, state the equation, define each variable, and give the units for the *moment of inertia I*. What is the *moment of inertia I* equivalent to in translational motion?
   http://hyperphysics.phy-astr.gsu.edu/hbase/mi.html#mi

6. Define, state the equation, define each variable, and give the units for *torque*.
https://openstax.org/books/university-physics-volume-1/pages/10-6-torque

7. State the equations for Newton's second law of motion for linear motion and Newton's second law of motion for rotational motion.
https://openstax.org/books/university-physics-volume-1/pages/10-7-newtons-second-law-for-rotation

8. Define and give the condition for *translational equilibrium* and *rotational equilibrium.*
http://hyperphysics.phy-astr.gsu.edu/hbase/torq.html#equi

9. State the equations for *translational kinetic energy* and *rotational kinetic energy*.
http://hyperphysics.phy-astr.gsu.edu/hbase/mi.html#rlin

10. State the equations for *power for linear motion* and *power for rotational motion*.
https://openstax.org/books/university-physics-volume-1/pages/10-8-work-and-power-for-rotational-motion

11. State the equations for *linear momentum* and *angular momentum*.
https://openstax.org/books/university-physics-volume-1/pages/11-3-conservation-of-angular-momentum

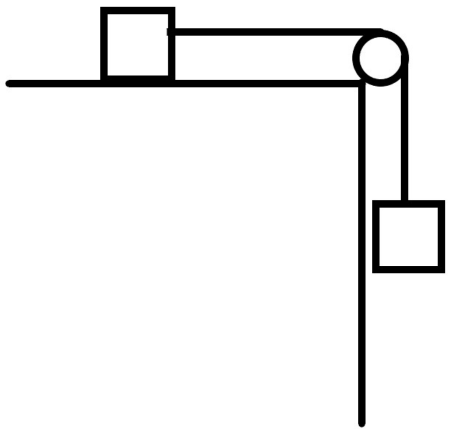
12. State the *law of conservation of linear momentum* and the *law of conservation of angular momentum*. Also state their equations.
https://openstax.org/books/university-physics-volume-1/pages/11-3-conservation-of-angular-momentum

Part 3: Answer the following questions

1. A solid chocolate sphere with a mass of 9 kg and a diameter of 80 cm is placed on top of a rough incline ($\mu = 0.7$) with a length of 6 m at an angle of 50 degrees. The solid chocolate sphere begins from rest and rolls down the incline.
   a. Draw a figure.
   b. What is the initial height of the solid chocolate sphere?
   c. How many revolutions will it take for the solid chocolate sphere to reach the bottom of the incline?
   d. What will be the final linear speed of the solid chocolate sphere at the bottom of the incline?
   e. What will be the final angular speed of the solid chocolate sphere at the bottom of the incline?
   f. What will be the angular acceleration of the solid chocolate sphere?
   g. What will be the linear acceleration of the solid chocolate sphere?
   h. How long will it take for the solid chocolate sphere to reach the bottom of the incline?

2. A solid chocolate sphere with a mass of 8 kg and a diameter of 70 cm is rolling to the right on a frictionless horizontal surface with a linear speed of 6 m/s. The surface then becomes rough with a coefficient of dynamic friction of 0.15.
   a. Draw a figure.
   b. What is the angular speed of the solid chocolate sphere as it rolls along the frictionless horizontal surface?
   c. What is the angular acceleration of the solid chocolate sphere as it travels along the rough surface?
   d. What is the linear acceleration of the solid chocolate sphere as it travels along the rough surface?
   e. How many revolutions does the solid chocolate sphere complete as it travels along the rough surface?
   f. How long does it take for the solid chocolate sphere to stop along the rough horizontal surface?

3. A block of mass $m_1 = 7\ kg$ sits at rest on a horizontal surface with $\mu = 0.2$. Mass m_1 is attached to a massless string which is wrapped around a pulley. Another massless string is wrapped around the same pulley and is holding another block of mass $m_2 = 47\ kg$ in the air. The pulley is a cylinder which has a mass of $m_C = 12\ kg$ and diameter of 10 cm.



a. Draw a free body diagram.
b. What is the common linear acceleration of the system?
c. What is the force of tension on the two massless strings?

4. A thin disk with a mass of 250 g and diameter of 40 cm is spinning with an angular speed of 3 rad/sec. A point mass with a mass of 350 g strikes and sticks to the top of the thin disk 4 cm from the edge. What is the final angular speed of the system?

5. A ladder, which has a mass of 20 kg and is 6 m long, is leaning against a frictionless wall. The ladder is at rest and makes an angle of 30 degrees from the wall. Draw a figure and write down the equations for static equilibrium.

Name: ________________________

Class: ________________________

Due Date: ________________________

B2 Thermodynamics

Understandings

- The first law of thermodynamics
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/firlaw.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/3-3-first-law-of-thermodynamics
- The second law of thermodynamics
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/seclaw.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/4-introduction
- Entropy
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/seclaw.html#c4
  https://openstax.org/books/university-physics-volume-2/pages/4-6-entropy
- Cyclic processes and pV diagrams
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heaeng.html#c2
  http://studyphysics.ca/2007/20/ap_thermodynamics/42c_ap_PV_diagrams.pdf
  https://openstax.org/books/university-physics-volume-2/pages/3-4-thermodynamic-processes
- Isovolumetric, isobaric, isothermal, and adiabatic processes
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/cvpro.html#c1
  https://www.thermal-engineering.org/what-is-isobaric-process-definition/
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/isoth.html#c1
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/adiab.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/3-4-thermodynamic-processes
  Carnot cycle
  http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/carnot.html#c1
  https://openstax.org/books/university-physics-volume-2/pages/4-5-the-carnot-cycle

- Thermal efficiency
  https://energyeducation.ca/encyclopedia/Thermal_efficiency

Equations

$$Q = \Delta U + W$$

$$U = \frac{3}{2}nRT$$

$$\Delta S = \frac{\Delta Q}{T}$$

$$pV^{5/3} = constant\ (for\ monatomic\ gases)$$

$$W = p\Delta V$$

$$\eta = \frac{useful\ work\ done}{energy\ input}$$

$$\eta_{carnot} = 1 - \frac{T_{cold}}{T_{hot}}$$

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

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

Answer the following questions

1. Consider a box/piston/system filled with an ideal gas and the equation for the law of conservation of energy $Q = \Delta U + W$.
   http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/firlaw.html#c1

   a. Define ΔU. What is the meaning if $\Delta U > 0\,Joules$? If $\Delta U = 0\,Joules$? If $\Delta U < 0\,Joules$?

   b. Define W. What is the meaning if $W > 0\,Joules$? If $W = 0\,Joules$? If $W < 0\,Joules$?

   c. Define Q. What is the meaning if $Q > 0\,Joules$? If $Q = 0\,Joules$? If $Q < 0\,Joules$?

2. Define *thermodynamics.*
   www.dictionary.com

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

4. State the *zeroth law of thermodynamics.*

5. State the *first law of thermodynamics.*
   http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/firlaw.html#c1

6. What does the area under a pressure-volume curve tell us?

   a. Define *isothermal process.*
      http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/isoth.html

   b. Define *isobaric process*.
      http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/cppro.html

   c. Define *isochoric/isovolumetric process*.
      http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/cvpro.html

d. Define *adiabatic process*.
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/adiab.html

7. **Use a pencil!** Draw and label a $P - V$ diagram below. Draw an *isobaric process* and an *isochoric/isovolumetric process*.

8. **Use a pencil!** Draw and label a $P - V$ diagram below. Draw three *isothermal processes (isotherms)* and an *adiabatic process*.

9. Define *entropy* S.
https://openstax.org/books/university-physics-volume-2/pages/4-6-entropy

10. What are the units of *entropy* S?

11. State the *second law of thermodynamics.*
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/seclaw.html#c1

12. State the *Clausius version* of the *second law of thermodynamics.*
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/seclaw.html

13. State the *Kelvin version* of the *second law of thermodynamics.*

14. State the *arrow of time* and *entropy* in terms of the second law of thermodynamics.
http://hyperphysics.phy-astr.gsu.edu/hbase/Therm/entrop.html#e2

15. The change in entropy S of a system is defined as $\Delta S = Q/T$.
    a. What can we do to make ΔS positive?

    b. What can we do to make ΔS negative?

16. State the *third law of thermodynamics.*
https://openstax.org/books/chemistry-2e/pages/16-3-the-second-and-third-laws-of-thermodynamics

17. Define *heat engine* and *heat pump.*
https://openstax.org/books/physics/pages/12-4-applications-of-thermodynamics-heat-engines-heat-pumps-and-refrigerators
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heaeng.html

18. **Use a pencil!** Carefully and clearly draw the *Carnot cycle*. Label the x-axis and the y-axis. Label the adiabatic processes and isothermal processes.
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/carnot.html

19. In general the efficiency of an engine is $\eta = \frac{useful\ work\ done}{energy\ input}$. For a $Carnot\ engine\ \eta_{carnot} = 1 - \frac{T_{cold}}{T_{hot}}$.

a. Is the *Carnot cycle* a fast or slow process?

b. Is the *Carnot cycle* realistic?

c. Is the *Carnot cycle* efficient?

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B3 Fluids

Understandings

- Density and pressure
- Buoyancy and Archimedes' principle
- Pascal's principle
- Hydrostatic equilibrium
- The ideal fluid
- Streamlines
- The continuity equation
- The Bernoulli equation and the Bernoulli effect
- Stokes' law and viscosity
- Laminar and turbulent flow and the Reynolds number

Equations

$$F_{buoyant} = \rho_{fluid} V_{fluid} g$$

$$\frac{1}{2}\rho {v_1}^2 + \rho g z + P = constant$$

$$P = P_0 + \rho_{fluid} g d$$

$$F_{drag} = 6\pi\eta r v$$

$$A_1 v_1 = constant$$

$$R = \frac{v r \rho}{\eta}$$

<u>Peruvian Diver Left Looking Like a Balloon after Rising from the Depths Too Fast</u>

https://www.odditycentral.com/news/peruvian-diver-left-looking-like-a-balloon-after-rising-from-the-depths-too-fast.html

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. Define *fluid*.

2. State the equation for *density* ρ, define each variable, and give the units for each variable. Is *density* a scalar or a vector?

3. What is the density of pure water? Include units!

4. What is the average density of salt water? Include units!

5. What is the average density of a human body? Include units!

6. Will it be easier or more difficult to swim (or stay afloat) if the density of a human is greater than salt water? Why?

7. Do dead bodies in the ocean salt water float or sink? Why?

8. Does oil in the ocean float or sink? Why?

9. Does metal (like gold) in the ocean float or sink? Why?

10. A dead fish is floating in the middle of the polluted radioactive ocean. Label the forces on the fish.

11. State the equation for *pressure P*, define each variable, and give the units for each variable. Is pressure a *scalar* or a vector?

12. Is it a good idea to wear high heels on grass? Why?

13. State the meaning and equation of the *buoyant force* (*force of buoyancy*).

14. State *Archimedes Principle*.

15. State the meaning and equation for *Pascal's Principle*.

16. Define a fluid in *hydrostatic equilibrium*.

17. Define *laminar flow*.

18. What do *streamlines* tell us?

19. What are the characteristics/conditions for an *ideal fluid*?

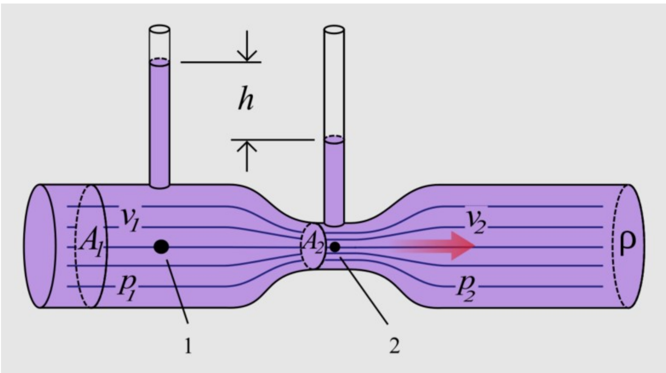
20. State the *continuity equation*. Define each variable and draw and label an image.

21. State *Bernoulli's equation* and define each variable.

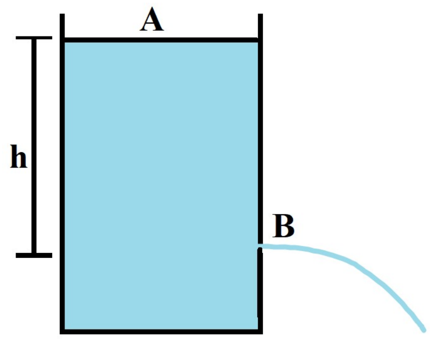
22. State the *Bernoulli effect*.

23. Describe how the *Bernoulli effect* relates to the Pitot tube to determine the speed of an airplane.

24. Use the Bernoulli equation and the continuity equation to determine the difference in pressure of a fluid in the throat of a cylinder if we are given the radius r_1 and r_2 the speed v_1.



25. Determine the initial horizontal speed of a liquid pouring out of a hole from a container as shown in the figure below:



26. Define *viscosity*.

27. State the meaning of and give the equation to *Stoke's law*.

28. Define turbulent flow.

29. State the meaning, equation, and define each variable for the *Reynold's number R*.

Part 2: Watch and take notes on the following videos

Physics - Mechanics: Fluid Statics: What is Buoyance Force? (1 of 9) Fraction Submerged
Michel Van Biezen
https://www.youtube.com/watch?v=BSKRz18bWRo
Watch and take notes on all the videos in the playlist!

Physics - Fluid Statics (1 of 10) Pressure in a Fluid
Michel Van Biezen
https://www.youtube.com/watch?v=mzjlAla3H1Q
Watch and take notes on all the videos in the playlist!

Physics Fluid Flow (1 of 7) Bernoulli's Equation
Michel Van Biezen
https://www.youtube.com/watch?v=brN9citH0RA
Watch and take notes on all the videos in the playlist!

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B4 Forced Vibrations and Resonance

Understandings

- Natural frequency
- Q factor and damping
- Periodic stimulus and the driving frequency
- Resonance

Equations

$$Q = 2\pi \frac{energy\ stored}{energy\ dissipated\ per\ cycle}$$

$$Q = 2\pi \times resonant\ frequency \times \frac{energy\ stored}{power\ loss}$$

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

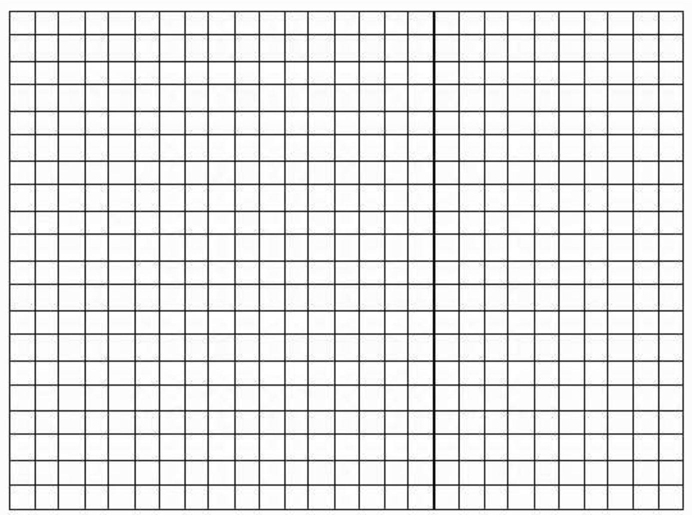
https://www.youtube.com/@gophysicsgo/playlists

1. What is a *restoring force*?

2. What are some characteristics for *simple harmonic motion*?

3. Define *free oscillation*.

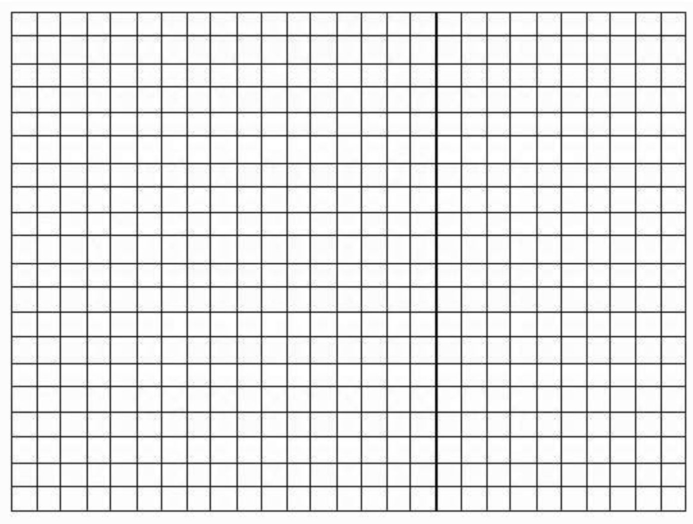
4. **Use a pencil!** Label and draw a displacement vs. time graph for a *free oscillation*.



5. Define *damping*.

6. Define *underdamping* (or *light damping*).

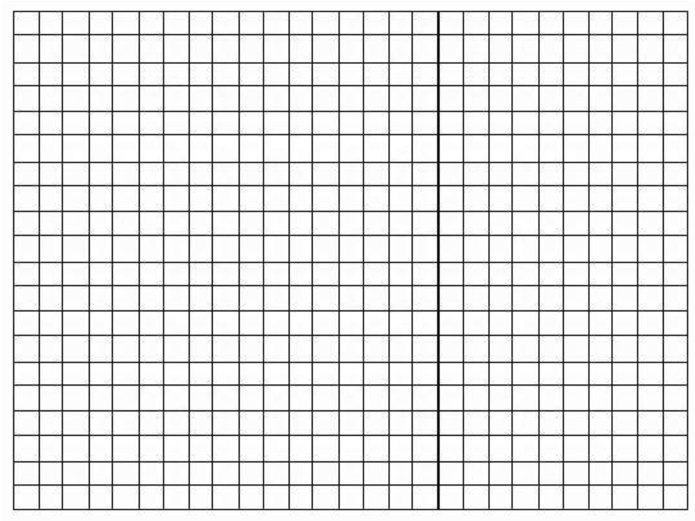
7. **Use a pencil!** Label and draw a graph for an *underdamped system*.



8. State the equations for the *quality factor Q*. What are the units for *Q*? What does a large *quality factor Q* tell us? What does a small *quality factor Q* tell us?

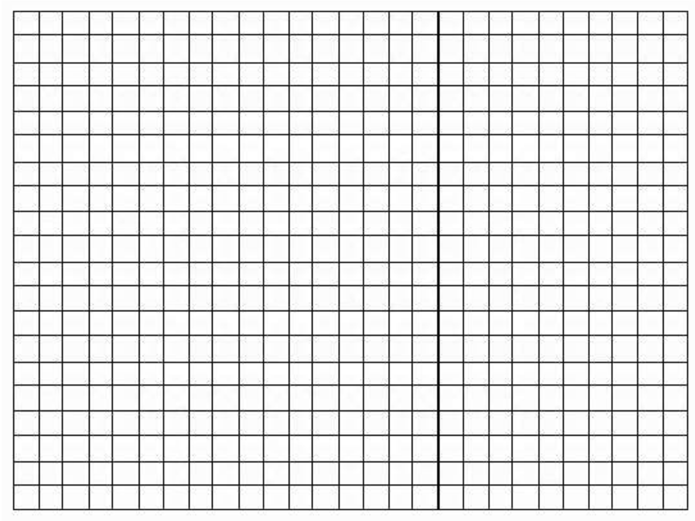
9. Define *overdamped motion*.

10. **Use a pencil!** Label and draw a graph for an *overdamped system*.



11. Define *critically damped motion*.

12. **Use a pencil!** Label and draw a graph for a *critically damped system*.



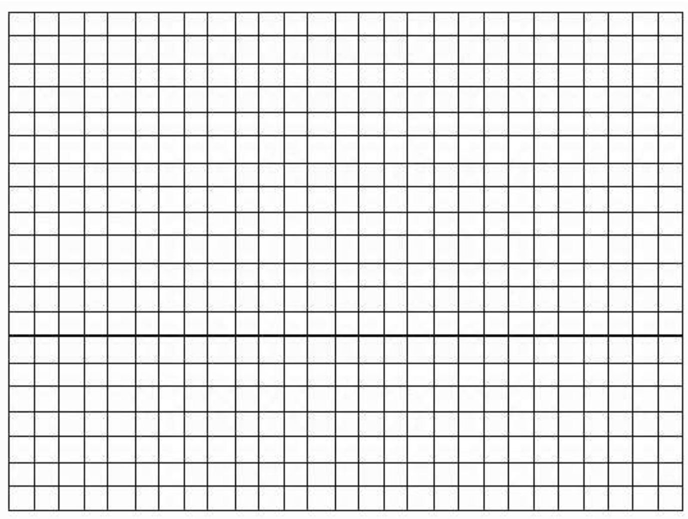
13. What is a *driving force*?

14. Define *natural frequency*.

15. What happens to the amplitude of an object when the *natural frequency* f_0 of the object is much lower or much higher than the *driving frequency* f_0?

16. What happens to the amplitude of an object when the *natural frequency* f_0 of the object is approximately equal to the *driving frequency* f_0?

17. Draw an *amplitude vs. frequency* graph of an object oscillating with a driving force and a damping force.



18. Define *resonance*.

19. List some effects of resonance in the real world.
   a.
   b.
   c.
   d.