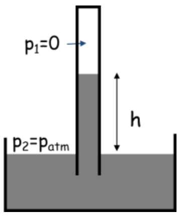
Name: ______________________________ DISC: __________

Q1	Q2	Q3	Q4
5	5	5	5

- Do your own work.
- Answer the questions below in the space provided.
- Make sure you show all your work and any equations that you use.
- Please place a box around your answers.
- Remember to give the correct units with all numerical answers

1. A barometer can be used to measure atomspheric pressure (P_{ATM}). In a barometer an evacuated tube is inserted into a pool of liquid, usually mercury. Let's investigate what happens:

Explanation (2pts):



ρ MERCURY	P_1	P_2
$13{,}600\,\frac{kg}{m^3}$	$0\ Pa$	UNKNOWN

a. Why is the height of the mercury in the tube related to the atmospheric pressure? **(Lecture 18, pp. 11-12)**

   i. The air, which has mass, pushes down on the pool of mercury. The force is caused by gravity.

   ii. The force of gravity causes pressure on the top of the pool of mercury.

   iii. In response the mercury rises up the evacuated tube governed by Pascal's Principle.

Pressure (3 pts):

b. You observe the height of mercury in the tube is $765\ mm$. Find the atmospheric pressure (hint: $P_{ATM} = P_1 + \rho g h$)

   i. $P_{ATM} = 0\ Pa + \left(13{,}600\ \frac{kg}{m^3}\right)\left(9.81\frac{m}{s^2}\right)(765\ mm)\left(\frac{1\ m}{1000\ mm}\right) = 102{,}063\ Pa = 102.06\ kPa$

2. Remarkably aircraft carriers don't sink in the ocean. Employ Archimedes' Principle to explain why. (Hint: You may approximate the carrier as a rectangle of area $A_{carrier}$.) **(Lecture 18, p. 14)**

ARCHIMEDES' PRINCIPLE	ρ_{sea}	ρ_{steel}
$F_B = \rho_{fluid} V_{displaced}\, g$	$1.025\ g/ml$	$7.9\ g/ml$

Floating Carriers (5 pts):

a. Archimedes' Principle describes the behavior of solid objects in fluids, such as sea water.

b. Archimedes' Principle states that if an object is able to displace its mass is the fluid it will float. That is: $\rho_{fluid} V_{fluid} = \rho_{solid} V_{solid}$. [5 pts if you got this far!]

c. Now for dense materials, geometry is important. If I assume that an aircraft carrier is a rectangle, I know the volume of the rectangle is $V_{carrier} = h_{carrier} A_{carrier}$. So as long as the top of the carrier $h_{carrier}$ is above water, the carrier will float.

d. Using this approximation: $\frac{m_{carrier}}{\rho_{sea} A_{carrier}} < h_{carrier}$ and we know that $m_{carrier} = \rho_{sea} V_{sea}$ where V_{sea} is the volume of the ocean that is displaced by the carrier.

e. Ocean-going vessels are able to float because of their geometry and the ocean is extremely large, so there is a large volume of water to displace the mass of the ship.

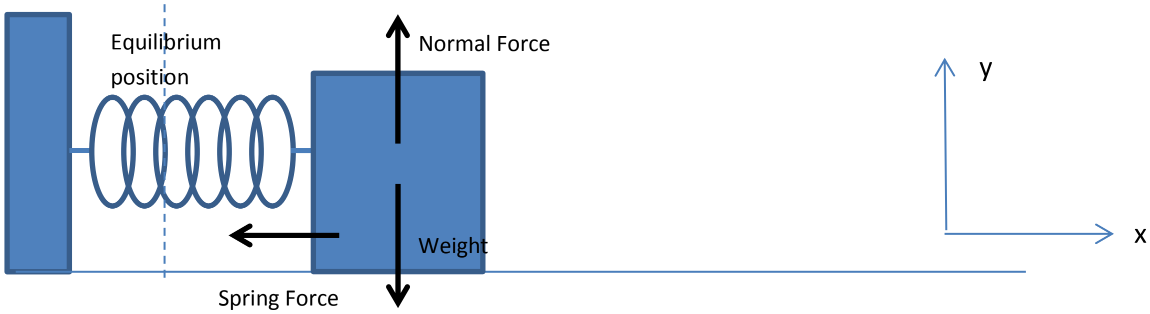
3. Hook's Law, $F_{spring} = -kx$, describes the force exerted on an object by a spring.

Answer:

a. An object is attached to a horizontal spring and rests on a frictionless surface. The spring is displaced from the equilibrium position. Does the object experience *constant* acceleration (yes/no)?

b. Draw a free-body diagram describing the situation in part (a). Remember to include a coordinate system and all force labels.

Free-body Diagram (2pts):



c. Using $U_{spring} = \frac{1}{2}kx^2$ and *energy conservation* explain why the *speed* of the object depends on its *position* (x). Let the initial displacement of the spring be $x_{initial}$. **(Lecture 20, p. 11)**

Explanation (2 pts):

i. From conservation of energy we know that the total energy at all times must be equal to the initial energy of the system, in this case: $U_{spring} = \frac{1}{2}kx_{initial}^2$.

ii. We know that total energy at any time is: $U + K = \frac{1}{2}kx^2 + \frac{1}{2}mv^2 = \frac{1}{2}kx_{initial}^2$

iii. I can now solve for v: $v^2 = \frac{k}{m}(x_{initial}^2 - x^2)$. So, $v = \sqrt{\frac{k}{m}(x_{initial}^2 - x^2)}$ which is clearly a function of the position of the object!

4. Foucault's Pendulum is a simple harmonic oscillator. It was used to demonstrate the rotation of the earth.

Answer:

a. Does Foucault's Pendulum experience constant acceleration (yes/no)?

b. If the pendulum length is 30 m, use $T = 2\pi\sqrt{\frac{L}{g}}$ to find the period of the pendulum's swing. **(Lecture 21, p. 18)**

Period (2 pts):

i. $T = 2\pi\sqrt{\frac{30\ m}{9.81\ m/s^2}} = 10.99s$

c. Now take your Foucault's Pendulum to another planet. You want to measure the acceleration of gravity. You set up your pendulum and notice that $T = 3T_{Earth}$. What is the acceleration of gravity on the new planet, g_{new}? **(Lecture 21, p. 18)**

g_{new} (2 pts):

i. $g = \frac{(2\pi)^2L}{T^2} = \frac{(2\pi)^2(30\ m)}{(3*10.99s)^2} = 1.09\ m/s^2$