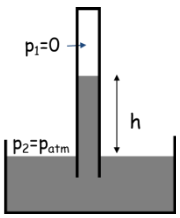
Name: ______________________________ DISC: __________

- 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

Q1	Q2	Q3	Q4
5	5	5	5

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, in this case olive oil. Let's investigate what happens:

Explanation (2pts):



ρ Olive Oil	P_1	P_{ATM}
$800\ kg/m^3$	$0\ Pa$	$101325\ Pa$

a. Why is the height of the olive oil 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 oil. The force is caused by gravity.**

ii. **The force of gravity causes pressure on the top of the pool of olive oil.**

iii. **In response the olive oil rises up the evacuated tube governed by Pascal's Principle.**

b. How long must the tube be to measure the atmospheric pressure using alcohol? (hint: $P_{ATM} = P_1 + \rho g h$)

Pressure (3 pts):

i. $\boldsymbol{P_{ATM} = P_1 + \rho g h = 0\ Pa + \left(800\frac{kg}{m^3}\right)\left(9.8\frac{m}{s}\right) h = 101325\ Pa}$

ii. $\boldsymbol{h = \frac{(101325\ Pa)}{\left(800\frac{kg}{m^3}\right)\left(9.8\frac{m}{s}\right)} = 12.92\ m}$

For this most part this problem went well. If the description of Pascal's Principle given by the student makes reasonable sense full credit for part a.

Part b. generally went fine—occasional arithmetic/algebra mistakes (-1pt ea.).

2. Remarkably steel ships do not sink in the ocean. Employ Archimedes' Principle to explain why.

(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):

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

ii. **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!]**

iii. **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.**

iv. **Also, ships have air spaces which help to reduce the average density of the ship.**

Generally speaking any correct recourse to Archimedes' Principle describing the ability of the very large ocean to displace the weight of the steel in the ship is acceptable for full credit.

Rubbish gets no credit (most students should get full credit for this problem).

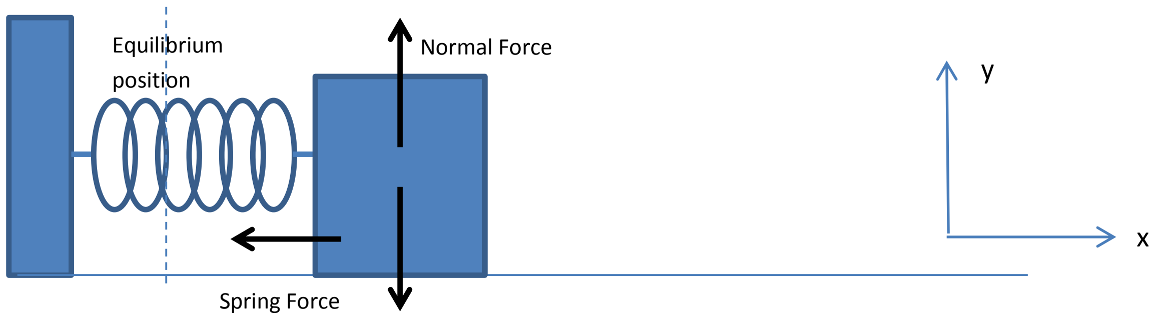
2. Hook's Law, $F_{spring} = -kx$, describes the force exerted on an object by a spring.

Answer:

a. An object is attached to a horizontal spring and rests on a frictionless surface. The spring is displaced from the equilibrium position.
The object *does <u>not</u> experience constant* acceleration (choose one): **true**/**false**?

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:** $\boldsymbol{U_{spring} = \frac{1}{2}kx^2_{initial}}$.

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

iii. **I can now solve for** v: $\boldsymbol{v^2 = \frac{k}{m}(x^2_{initial} - x^2)}$.

iv. **So,** $\boldsymbol{v = \sqrt{\frac{k}{m}(x^2_{initial} - x^2)}}$ **which is clearly a function of the position of the object!**

Free-body diagram: -1 pt for missing weight and normal force; - 1 pt for incorrect/unlabeled forces.

3. 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? Explain you answer.

Foucault's Pendulum does not experience constant acceleration. It is a simple harmonic oscillator, and the restoring force it experiences is dependent on position.

Period (2 pts):

b. If the pendulum length is 8 m, use $T = 2\pi\sqrt{\frac{L}{g}}$ to find the period of the pendulum's swing. **(Lecture 21, p. 18)**

$$T = 2\pi\sqrt{\frac{8\ m}{9.81\ m/s^2}} = 5.67\ s$$

g_{new} (2 pts):

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 $T = 2T_{Earth}$. What is the acceleration of gravity on the new planet, g_{new}? ? **(Lecture 21, p. 18)**

$$g = \frac{(2\pi)^2 L}{T^2} = \frac{(2\pi)^2 (8\ m)}{(2\ \times 5.67\ s)^2} = 2.46\ m/s^2$$

Students either executed this problem correctly or they did not. The major issues were:

1) **Not realizing that a pendulum is a SHO (-1 pt)**
2) **Algebra/arithmetic mistakes (-1 pt ea)**