KEY

NAME

ONID

PH 202 MID TERM #3

Instructions:

Do not open the test until prompted to do so.

Read all the questions thoroughly and ask if you have any questions.

You have 40 minutes to complete the test.

You may use:

Up to 10 pages of notes of any kind

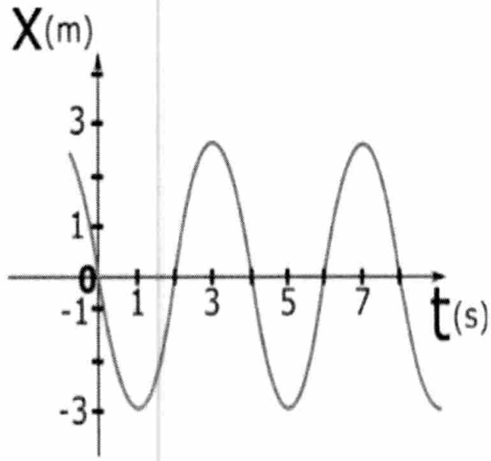
A non-communicating calculator

Your brain

Points break-down for each problem:

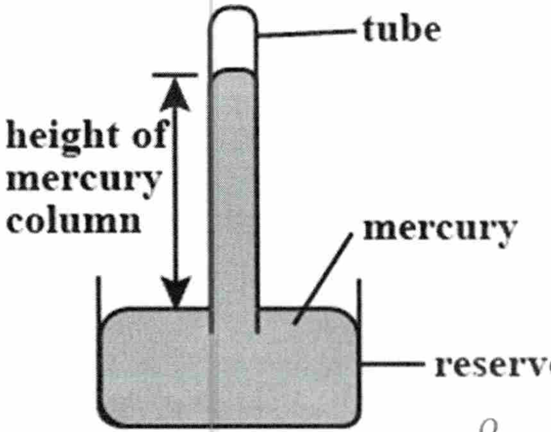
Question #1	4 points
Question #2	3 points
Question #3	3 points
Question #4	20 points
Question #5	20 points
Total	50 points

1) (4 pts) An ideal mass on a spring is oscillating on a frictionless horizontal plane as shown on the graph below. Select the below options that are correct for this system.



a. The natural frequency of the system is dependent on the length of the spring.
b. Increasing the mass increases the frequency of the spring.
c. Increasing the mass increases the period of the spring oscillation.
d. The system is constantly interchanging spring potential energy with kinetic energy.
e. The system is constantly interchanging kinetic energy, spring potential energy, and gravitational potential energy.
f. The net energy of the system is increasing.
g. The net energy of the system is constant.
h. The net energy of the system is decreasing.
i. If friction were not negligible, the amplitude of the oscillations would decrease over time.
j. This system is overdamped.

2) (3 pts) A mercury barometer consists of a glass tube that is capped on the top and open on the bottom. The tube is sitting in a pool of mercury (13.5 g/cm^3) and is marked so that the height of mercury can be measured (typically in millimeters). Assuming standard atmospheric pressure (101.3 kPa) outside and a vacuum in the top of the tube, calculate the height of mercury that the barometer will measure.



a. 0.76 mm
b. 760 mm
c. 7.5 mm
d. 7500 mm

$P_{ATM} = \rho g h \Rightarrow h = \frac{P_{ATM}}{\rho g}$

$\frac{13.5 g}{cm^3} \cdot \frac{1 Kg}{1000 g} \cdot \left(\frac{100 cm}{1 m}\right)^3 = 13500 \frac{Kg}{m^3}$

$h = \frac{101300 \, Pa}{(13500 \frac{kg}{m^3})(9.81 \frac{m}{s^2})} = 0.765 m \approx \boxed{760 mm}$

3) (3 pts) If your barometer is measuring standard atmospheric pressure in Corvallis, OR (elevation 70 meters), what will the pressure reading be in Bend, OR (elevation 1,100 meters)? (air density = 1.293 kg/m^3)

a. 114 kPa
b. 102 kPa
c. 100 kPa
d. 88 kPa

$P_{COR} + \frac{1}{2}\rho \cancel{V_{COR}^2} + \rho g \underbrace{h_c}_{70 \text{ METERS}} = P_{BEND} + \frac{1}{2}\rho \cancel{V_{BEND}^2} + \rho g \underbrace{h_B}_{1100 m}$

0 0

$P_{BEND} = P_{COR} + \rho g (h_c - h_{BEND})$

$P_{BEND} = 101.3 \, KPa + (1.293 \, kg/m^3)(9.81 \, m/s^2)(70m - 1100m) = 88 \, kPa$

4) A 500 kg wrecking ball is often used in construction to demolish a structure and can be modeled as a simple pendulum. Assuming that a wrecking ball hanging from a 15-meter cable is released from rest at a 15-degree angle, answer the questions below:

(3 pts) What is the angular frequency of the pendulum?

$$\omega = \sqrt{\frac{g}{\ell}} = \sqrt{\frac{9.81\,m/s^2}{15\,m}} = \boxed{0.809\ rad/sec}$$

(3 pts) What is the period of the pendulum?

$$\omega = 2\pi f = 2\pi/T \Rightarrow T = \frac{2\pi}{\omega} = \frac{2\pi}{0.809\ rad/sec} = \boxed{7.77\ sec}$$

(3 pts) Write down an equation of motion that describes the motion of the wrecking ball. Include all relevant numbers.

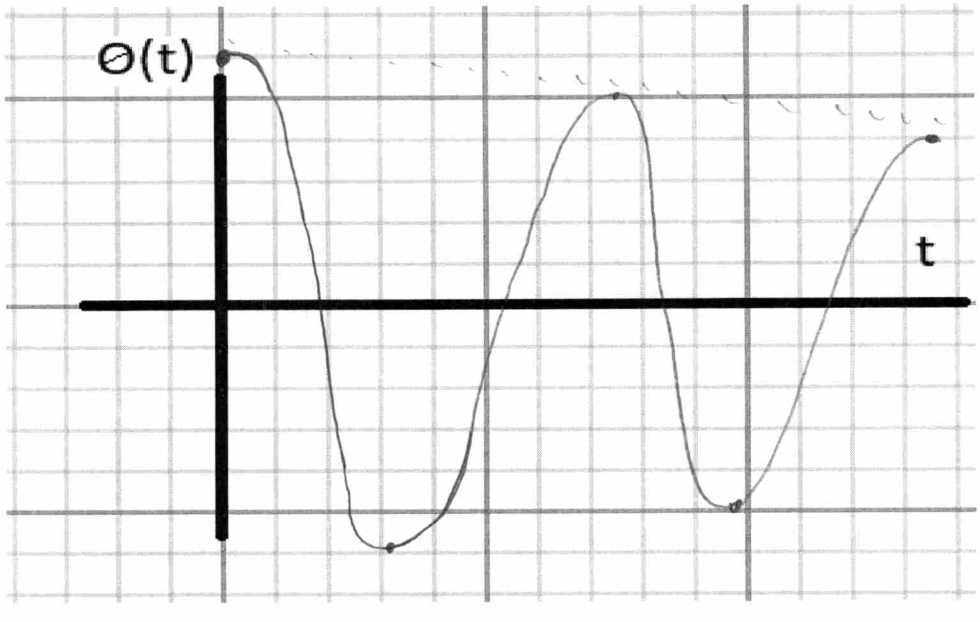
$$\boxed{\theta(t) = 15^\circ \cos(0.809\ rad/s \cdot t)}$$

(3 pts) Now, after oscillating for 90 seconds, the maximum angle of the wrecking ball is measured to be 12 degrees from equilibrium. What is the time constant for the pendulum's decay?

AMPLITUDE

$$\theta(t) = \theta_{MAX}^{t=0}\, e^{-t/\tau} \Rightarrow \tau = \frac{-t}{\ln\left(\frac{\theta(t)}{\theta_{MAX}}\right)} = \frac{-90\ sec}{\ln\left(\frac{12^\circ}{15^\circ}\right)} = \boxed{403\ sec}$$

(5 pts) On the graph below, draw a depiction of the decaying pendulum motion with at least two full oscillations. What is the equation for the displacement of the wrecking ball?



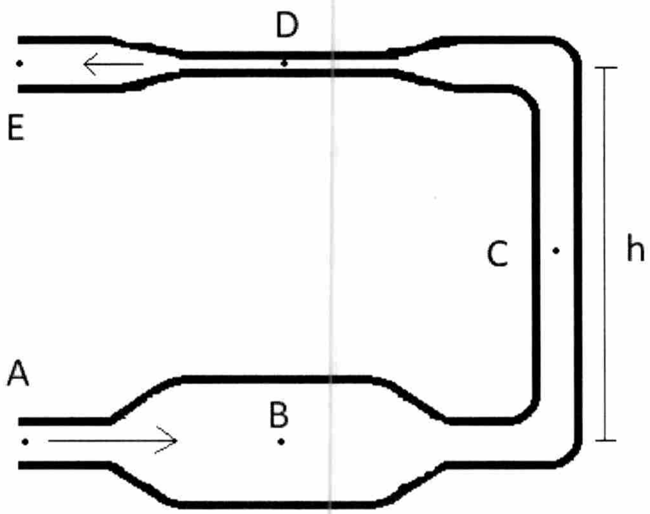
$$\boxed{\theta(t) = 15^\circ e^{-t/403\,sec} \cos(0.809\ rad/sec\ t)}$$

(3 pts) Now, Miley Cyrus (70 kg) jumps onto the wrecking ball to add a driving force to the pendulum and keep its motion from decaying. What driving angular frequency must she use for her force to optimize her efforts?

$$\omega = \sqrt{\frac{g}{\ell}} \Rightarrow \text{NO MASS IMPACT}$$

$$\boxed{\omega_{DRIVING} = 0.809\ rad/sec}$$

5) A pipe system is shown in the diagram below. Water (density = 1000 kg/m^3) is flowing in at point A at a pressure of 150 kPa with a flow rate of 3 cubic meters per second. The radius of the pipe at point A, C, and E is 0.05 meters. The top pipe is a height h = 1.5 meters above the bottom pipe. Analyze the following questions:



(2 pts) What is the velocity of the water at point A?

$Q = VA \Rightarrow V = \frac{Q}{A}$

$V = \frac{0.03\ m^3/s}{\pi(0.05m)^2} = 3.82\ m/s$

(2 pts) What is the velocity of the water at point B assuming that the radius there is 0.1 meters?

$Q = V_A A_A = V_B A_B$

$V_B = \frac{Q}{A_B} = \frac{0.03\ m^3/s}{\pi(0.1m)^2} = \boxed{0.95\ m/s}$

(2 pts) What is the flow rate of the water at point D (assume the radius is 0.01 meters)?

$Q_D = Q_A = \boxed{0.03\ m^3/s}$

(4 pts) What is the highest pressure in the system?

@ PT B

$P_A + \frac{1}{2}\rho V_A^2 + \cancel{\rho g y_A} = P_B + \frac{1}{2}\rho V_B^2 + \cancel{\rho g y_B}$

$P_B = P_A + \frac{1}{2}\rho V_A^2 - \frac{1}{2}\rho V_B^2$

$P_B = 150kPa + \frac{1}{2}(1000\ kg/m^3)\left((3.82\ m/s)^2 - (0.95\ m/s)^2\right)$

$\boxed{P_B = 156.8\ KPa}$ @ B

@ PT C (4 pts) What is the lowest pressure in the system?

$P_A + \frac{1}{2}\rho V_A^2 + \cancel{\rho g y_A}^{0} = P_C + \frac{1}{2}\rho V_C^2 + \rho g y_C$ $Q = V_C A_C$

$V_C = \frac{Q}{A_C} = \frac{0.03\ m^3/s}{\pi(0.03m)^2} = 10.6\ m/s$

$P_C = P_A + \frac{1}{2}\rho(V_A^2 - V_C^2) + \rho g y_C = 150KPa + \frac{1}{2}(1000\ kg/m^3)\left((3.82\ m/s)^2 - (10.6\ m/s)^2\right) + (1000\ kg/m^3)(9.81\ m/s^2)(-1.5m)$

$150\ KPa - 49\ KPa - 14.7\ KPa$ $\boxed{P_C = 86.3\ KPa}$

(6 pts) Assume a 0.01 meter tube is added connecting point B and point D. In the middle of the tube at h/2 a movable diaphragm is added that can move up and down the tube, but it prevents the fluid from mixing. Describe the net force on and motion of the diaphragm. You can use equations, diagrams, graphs, words, or drawings to explain your reasoning.

$P_1 = P_C + \rho g \frac{1.5m}{2} = 86.3\ KPa + 7.4\ KPa = 93.7\ KPa$

$P_2 = P_B - \rho g \frac{1.5m}{2} = 156.8\ KPa - 7.4\ KPa = 149.4\ KPa$

$F_1 = \frac{P_1}{A}$

$F_2 = \frac{P_2}{A}$

$\Sigma F = F_2 - F_1 = \frac{P_2 - P_1}{A} = \frac{55.7\ KPa}{\pi(0.01m)^2} = \boxed{1.77 \cdot 10^8\ N}$

THE FORCE IS UPWARD DUE TO ΔP AND THE DIAPHRAGM WILL ALL UPWARD.