AP Physics Fall 2013
Test 12
(December 11)

Name: Key

Short Answer	_____	30 pts
Problem 10	_____	9 pts
Problem 11	_____	10 pts
Problem 12	_____	10 pts
Problem 13	_____	13 pts
Problem 14	_____	28pts
Bonus	_____	18 pts
Total	_____	

Name: _____

3 pts **1.** State the equation that a mechanical system must meet to be a simple harmonic oscillator.

accel. $= -\omega^2$ Displacement

or ↑ constant

$a = -\omega^2 x$

Take any of these

or

$\vec{F} = -k\vec{x}$

3 pts **2** State the definition of pressure (either in words or equation)

Pressure is force divided by area

or

$$P = \frac{F}{A}$$

6 ~~8~~ pts **3.** State the two conditions (either in words or equations) that must be met for a rigid body to be in equilibrium

1) The sum of the forces is zero (+3)

$$\Sigma \vec{F} = 0$$

2) The sum of the torques is zero (+3)

$$\Sigma \vec{\tau} = 0$$

3 pts **4.** State the condition required for a pendulum to be a simple harmonic oscillator.

The amplitude of the swings must be small.

or equivalently

Small angles

or equivalently

$\sin\theta \cong \theta$

Name: _____

3 pts **5.** State Archimedes' Principle in words.

Any object partially or fully submerged in a fluid experiences an upward buoyant force whose magnitude is equal to the weight of the displaced fluid.

3 pts **6.** State Pascal's Law (either in words or equation)

The pressure in a fluid increases with depth by a term equal to the product of the density of the fluid, acceleration of gravity, and the depth.

or

$$\boxed{P = P_0 + \rho g h} \quad \text{or} \quad \Delta P = \rho g h$$

3 pts **7.** Give the equation that relates the period of any simple harmonic oscillator to its angular frequency.

$$\boxed{T = \frac{2\pi}{\omega}} \quad \text{or} \quad \omega T = 2\pi$$

Name: _____

3 pts **8.** Give the equation for finding the angular frequency of a spring-mass oscillator.

$$\omega = \sqrt{\frac{k}{m}}$$

3 pts **9.** What principle tells us that the pressure of a fluid in a tube will decreases with higher speed?

Bernoulli's

Name: _____

9 pts **10.** A swimming pool is 8.5 m long and 6.5 m wide. The swimming pool is filled to a depth of 3.0 m.

4 pts **A.** What is the mass of the water?

(+1) $m = \rho V$

(+1) $V = (8.5\,m)(6.5\,m)(3.0\,m) = 165.75\,m^3$

$m = \left(1000\,\frac{kg}{m^3}\right)(165.75\,m^3) \cong \boxed{1.66 \times 10^5\,kg}$

(+1) # (+1) units

5 pts **B.** What is the absolute pressure at the bottom of the pool?

(+1) $P = P_0 + \rho g h$ "Pascal's Law"

$P = \left(1.013 \times 10^5\,\frac{N}{m^2}\right) + \left(1000\,\frac{kg}{m^3}\right)\left(9.8\,m/s^2\right)(3.0\,m)$

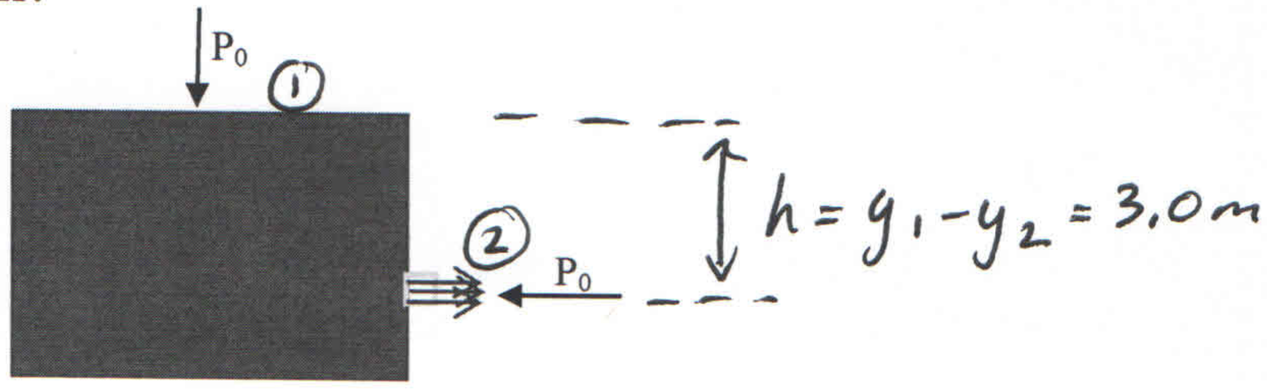
(+1) (+1)

$P \cong \boxed{1.31 \times 10^5\,Pa}$

(+1) # (+1) suitable unit including N/m^2

Name: _____

10 pts **11.** What volume of water will escape per second from an open-top tank through an opening 1.5 cm in diameter that is 3.0 m below the water level in the tank?



(+2) $P_0 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_0 + \frac{1}{2}\rho v_2^2 + \rho g y_2$ "Bernoulli's Eq"

$\Rightarrow \frac{1}{2}\rho v_1^2 + \rho g y_1 = \frac{1}{2}\rho v_2^2 + \rho g y_2$ (+1)

(+1) But $v_1 \cong 0$ m/s

$\Rightarrow \frac{1}{2}\rho v_2^2 = \rho g (y_1 - y_2) = \rho g h$

$\Rightarrow v_2^2 = 2gh$

$\Rightarrow$ (+1) $v_2 = \sqrt{2gh} = \sqrt{2(9.8 m/s^2)(3.0m)} \cong 7.668$ m/s

$\phi = \frac{\Delta V}{\Delta t} = v_2 A_2$ (+2) "Definition of Water Flux"

$A_2 = \pi \left(\frac{d}{2}\right)^2$ (+1)

$\phi \cong (7.668 m/s)\,\pi \left(\frac{0.015m}{2}\right)^2 \cong$ $1.36 \times 10^{-3} \frac{m^3}{s}$

or $1.136 \times 10^3 cm^3/s$

or $1.36 \times 10^3 ml/s$

or $1.36 l/s$

(+1) #

(+1) unit

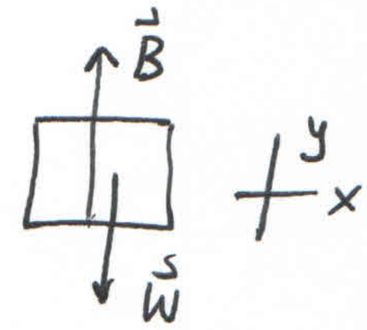
Name: _____

10 pts **12.** A cube with sides of 13 cm in length and a density of 0.49 g/cm^3 is floating in a fluid of density 0.93 g/cm^3.

6 pts **A.** What is the buoyant force upon the object?

(+1) Floating so B = weight of object

$B = mg = \rho_o V_o g$ (+1)



$\Sigma F_y = 0 = B - W$

$B = (490 \frac{kg}{m^3})(0.13\,m)^3(9.8\,m/s^2)$

(+1) (+1)

$B \cong \boxed{10.5\ N}$ — (+1) # — (+1) units

4 pts **B.** What percent of the object's volume was submerged?

(+1) $\frac{V_s}{V_o} = \frac{\rho_o}{\rho_f}$ "Archimede's result"

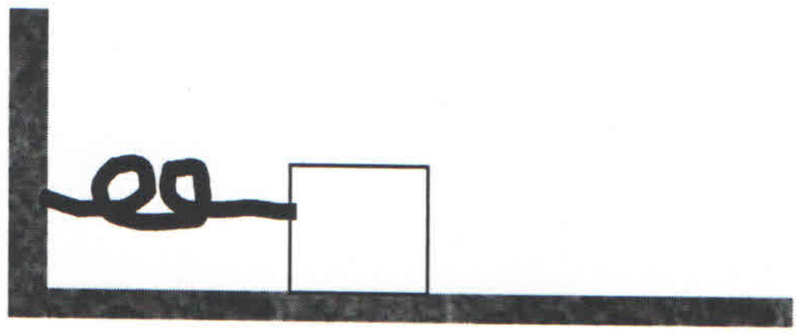
(+1) $\frac{V_s}{V_o} = \frac{0.49\,g/cm^3}{0.93\,g/cm^3}$

(+1) $\frac{V_s}{V_o} \cong 0.527$

$\Rightarrow \frac{V_s}{V_o}\% \cong \boxed{52.7\%}$ (+1)

Name: _____

13 pts **13.** A spring stretches 6.3 cm when a 1.4 kg fish hangs from it. The spring is then attached 0.85 kg block sliding on a frictionless surface to make a horizontal harmonic oscillator as shown below. The mass is then moved so the spring is stretched 12.3 cm and released from rest.



3 pts **A.** What is the spring stiffness constant?

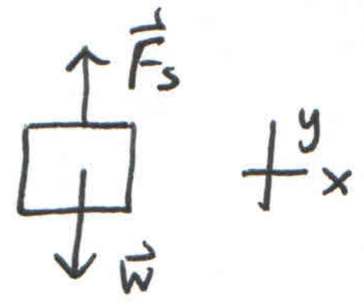
$\Sigma F_y = m a_y = 0$

$F_s - W = 0$

+1 $F_s = W$

+1 $kx = mg$

$k = \frac{mg}{x} = \frac{(1.4kg)(9.8m/s^2)}{0.063m} \cong$ **22.2 N/m** +1 Ans.



5 pts **B.** What is the period of oscillation?

$\omega = \sqrt{\frac{k}{m}} \Rightarrow T = \frac{2\pi}{\omega}$ (+2) $\Rightarrow T = 2\pi\sqrt{\frac{m}{k}}$ +1

$T \cong 2\pi\sqrt{\frac{0.85kg}{22.2N/m}} \cong$ **1.23 s** — +1 # — +1 units

5 pts **C.** What is the maximum speed of the mass?

$A = 0.123m$ +1

$v_{MAX} = A\omega = A\sqrt{\frac{k}{m}}$ (+2)

$v_{MAX} \cong (0.123m)\sqrt{\frac{(22.2N/m)}{0.85kg}}$

$v_{MAX} \cong$ **0.629 m/s** — +1 # — +1 units

Equivalently

$E = \text{constant} = K + U$

$\frac{1}{2}kA^2 = \frac{1}{2}m v_{MAX}^2$

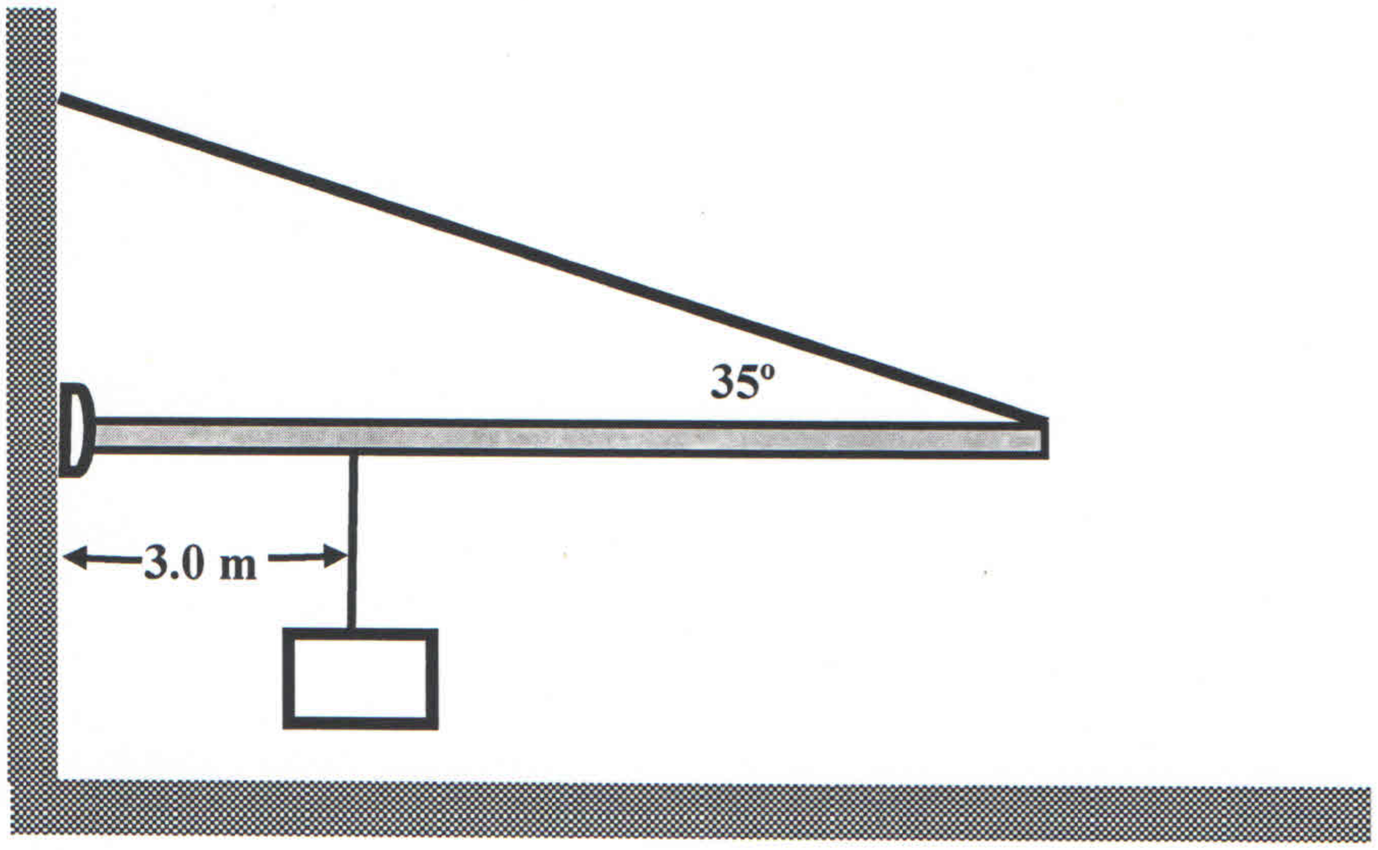
$v_{MAX}^2 = \frac{k}{m}A^2$

$v_{MAX} = \sqrt{\frac{k}{m}}A$

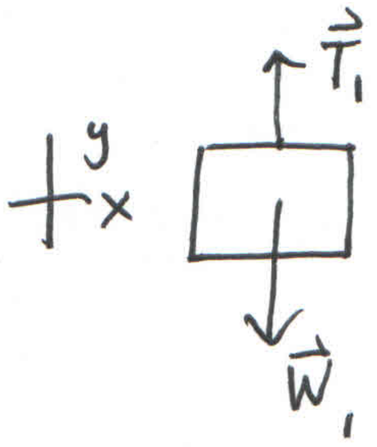
+2 ↑ Breakup points

Name: _____

28 pts **14.** A uniform 1200 N beam of length 8.0 m is hinged at one end to the wall and held on the other end by a rope attached to the wall as shown below. A 700 N block is attached to the beam by a second rope at a distance of 3.0 m from the wall.



8 pts **A.** Draw proper Free Body Diagrams for the beam and the block.

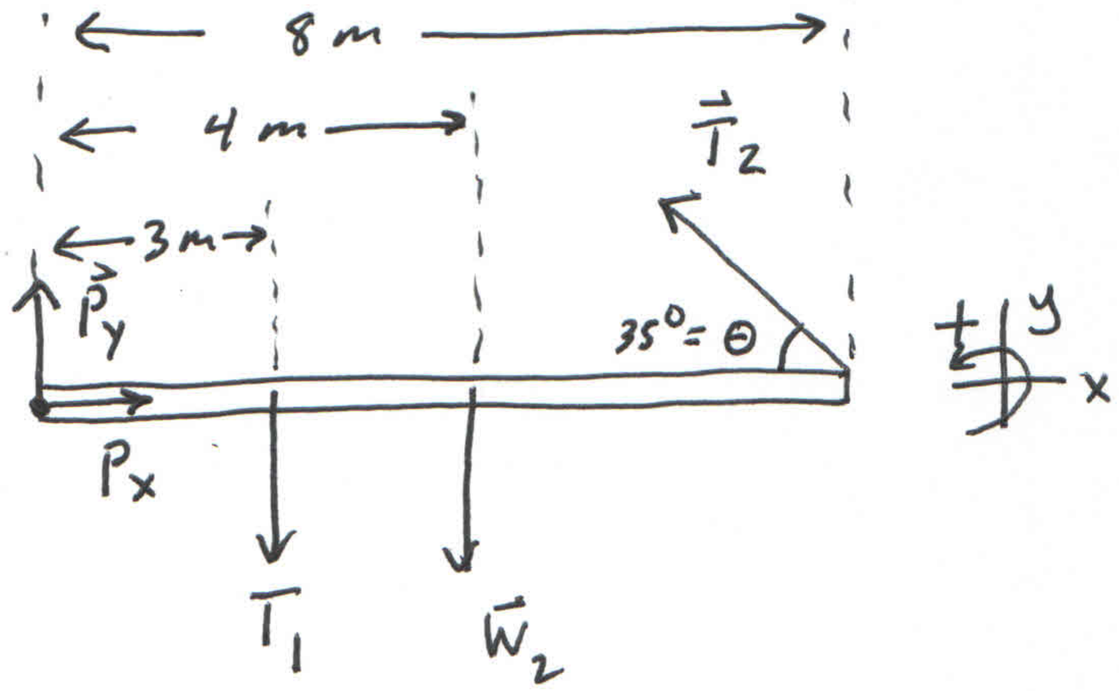


1) 2 force @ 0.5pts = 1.0pts

2) 1 axis @ 0.5pts = 0.5pts

3) isolated = 0.5pts

2.0pts



1) 5 forces @ ½ each = 2.5pts

2) 3 dimensions @ ½ each = 1.5pts

3) Angle @ ½ pts = 0.5pts

4) 1 axis with rotation @ 1pt = 1.0pts

5) Isolated body = 0.5pts

6pts

Name: _____

3 pts **B.** Find the tension in the rope holding the block.

$$\Sigma F_y = M_1 a_y = 0$$

$$T_1 - W_1 = 0$$

(+1) $T_1 = W_1$

$T_1 = \boxed{700\ N}$

(+1) # (+1) units

6 pts **C.** Find the tension in the rope attached to the wall.

(+1) $\Sigma \tau = 0$

$$-T_1(3m) - W_2(4m) + T_2 \sin(35°)(8m) = 0$$

(+1) (+1) (+1)

$$T_2 = \frac{W_2(4m) + T_1(3m)}{8m \sin(35°)}$$

$$T_2 \cong \frac{(1200N)(4m) + (700N)(3m)}{8m \sin(35°)}$$

$T_2 \cong \boxed{1504\ N}$

(+1) # (+1) units

Name: _____

11 pts **D.** Find the magnitude and direction of the force applied by the hinge upon the beam?

(+1) $\Sigma F_x = 0$

(+1) $P_x - T_2 \cos\theta = 0$

$P_x = T_2 \cos\theta$

$P_x \cong (1504N)\cos(35°)$

(+1) $P_x \cong 1232\,N$

(+1) $\Sigma F_y = 0$

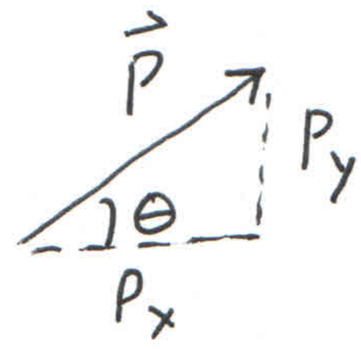
(+1) $P_y - T_1 - W_2 + T_2 \sin\theta = 0$

$P_y = T_1 + W_2 - T_2 \sin\theta$

$P_y \cong 700N + 1200N - (1504N)\sin(35°)$

(+1) $P_y \cong 1037\,N$

(+1) $P = \sqrt{P_x^2 + P_y^2}$



$P \cong \sqrt{(1232N)^2 + (1037N)^2} \cong \boxed{1{,}610\,N}$ — (+1) # — (+1) units

$\theta = \tan^{-1}\left(\frac{P_y}{P_x}\right) \cong \boxed{40.1°}$ — # (+1)

(+1)

Name: _____

BONUS PROBLEMS

4 pts **1.** What is the condition necessary for an object to float in a fluid?

Density of object must be less than or equal to the density of the fluid.

Don't count off if they only say less than

They can also write it in symbols
$\rho_o \leq \rho_f$

2. A simple pendulum is constructed from a bob with mass 0.25 kg and a string of length 2.3 m. The pendulum is released from rest at an angle of $\pi/10$ radians.

4 pts **A.** What is the pendulum's angular frequency?

$\omega = \sqrt{g/\ell}$ (+2)

$\omega = \sqrt{\frac{9.8 m/s^2}{2.3 m}} \cong$ **2.06 rad/s** — (+1) # — (+1) units

4 pts **B.** What is the pendulum's frequency in Hertz?

$f = \frac{\omega}{2\pi}$ (+2)

$f \cong \frac{2.06 \text{ rad/s}}{2\pi} \cong$ **0.328 Hz** — (+1) # — (+1) units

Name: _____

4 pts **3.** Give the value of 2.0 atmospheres in the following units:

A. bars

$1.013\ bars \times \frac{2\ atm}{1\ atm} \Rightarrow$ **2.026 bars** (+1) (+1) #

Also accept 2.02 or 2.03

B. torr

$\left(\frac{760\ torr}{1\ atm}\right)(2\ atm) =$ **1520 torr** (+1) (+1) #

2 pts **4.** An object has a density of 1450 kg/m^3. What is its specific density?

$\frac{1450\ kg/m^3}{1000\ kg/m^3} =$ **1.45** (+2)