First Letter Last Name Ans Key

Student # ______________ Name:______________________

Physics 101 –S101– Midterm 1 Oct 2004

Use the back of the formula sheet for rough work
Clearly show all your work
Use Pen or you cannot request a remark.

Question 1

(4)

A block of wood has a mass of 3.50 kg, and a density of 600 kg/m³. It is to be loaded with lead ($\rho_{Pb} = 1.13\times10^4$ kg/m³) so that it floats in water with 90% of its volume submerged.

Volume block $= \frac{m}{\rho} = \frac{3.50\,kg}{600\,kg/m^3} = 5.83\times10^{-3}\ m^3$

i) What mass of lead is needed if the lead is attached to the top of the block?

90% volume block $= 5.25\times10^{-3}\ m^3$

(3) mass water $5.25\times10^{-3}\,m^3$ displaces $= 1000\,\frac{kg}{m^3}\times5.25\times10^{-3}\,m^3 = 5.25\ kg$

Total mass needed to displace so 90% below is 5.25 kg

∴ need to add $(5.25 - 3.50) =$ **1.75 kg**

ii) If the lead was attached to the bottom of the block would you more or less lead? Explain!

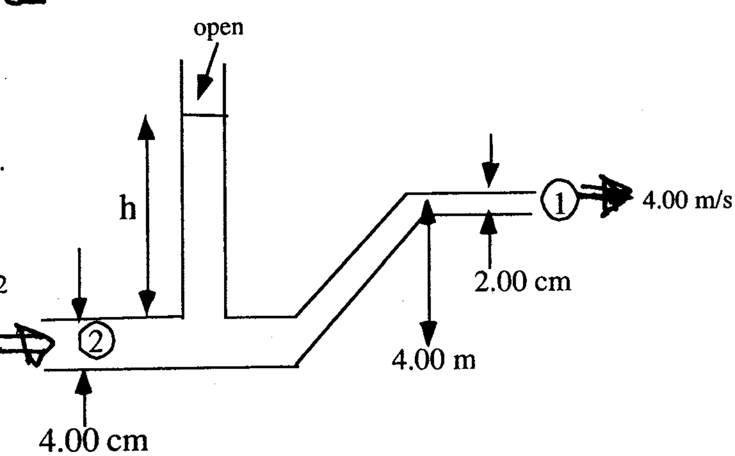
(1) If below water line also buoyant force due to Pb

∴ need **more** lead

Question 2

(5)

Water flows through the pipe system as shown (not to scale).
At point 1, the water exits the system into the air through a 2.00 cm diameter pipe at a speed of 4.00 m/s.
At point 2 the diameter of the pipe is 4.00 cm.



i) What is the pressure and speed of the water at point 2

$A_1 v_1 = A_2 v_2$

$v_2 = \frac{A_1}{A_2} v_1 = \frac{1}{4} v_1$

(1) ∴ $v_2 = 1.00\ m/s$

$P_2 + \frac{1}{2}\rho v_2^2 = P_0 + \frac{1}{2}\rho v_1^2 + \rho g y_1$

(3) $P_2 = P_0 + 500\,(16-1) + 1000\times9.81\times4.0\,m$

$= P_0 + 46740\ Pa$

Pressure $= 1.477\times10^5\ Pa$ or Gauge Pressure 46740 Pa

ii) What is the height, h, of the standing column of water?

$\Delta P = \rho g h$

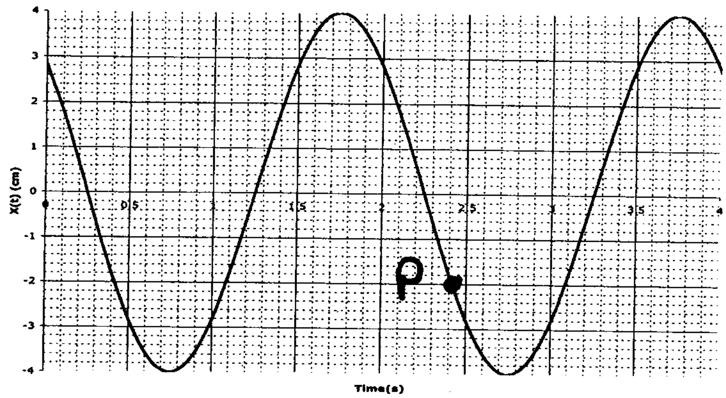
(1) $h = \frac{\Delta P}{g\rho} = \frac{46740}{9.81\times1000} =$ **4.76 m**

(6)

Question 3

The top graph shows the displacement of a particle undergoing simple harmonic motion.

i) What is the frequency of oscillation?



(1) $T = 2.0$ s

$\therefore$ **$f = 0.50$ Hz**

ii) What is the phase constant ϕ for the motion?

(2) $x(0) = 2.8$ cm $= 4.0\text{cm} \cos\phi$

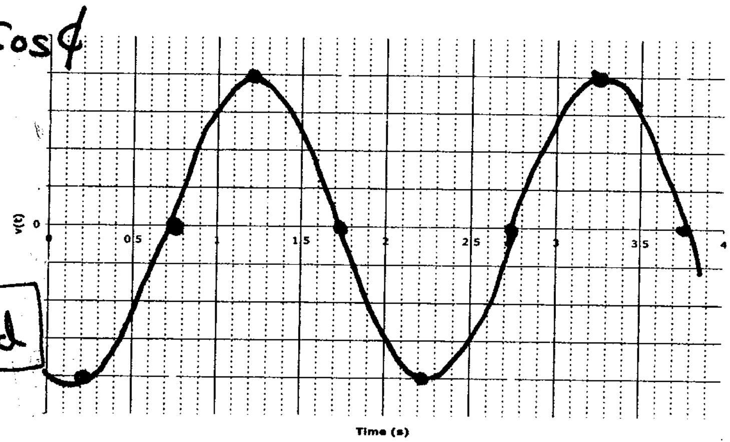
$\cos\phi = \frac{2.8}{4.0}$

$\phi = \pm 0.795$ rad

at $t = 0$ v is $-$ve

$\therefore$ **$\phi = +0.795$ rad**

($-\frac{1}{2}$ if not $\pm$)



iii) **Sketch** a graph (pencil is fine here) of velocity versus time for the same particle – be sure to align the graph vertically with the one above it. Indicate the value of the maximum velocity.

(2) $V_{max} = \omega A = \pi \times 4.0$ cm/s

$= $ **0.126 m/s**

iv) Place a dot on the circle below to show the position of a circular motion particle that would correspond to point P on the displacement graph above.

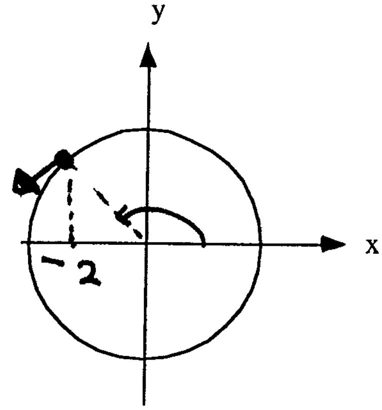
(1) At P $x = -2.0$ cm

& v is $-$ve

P is in 2nd quadrant

x ~~is~~ $-$ve here

& projection of velocity is in negative x direction



(3) **Question 4a**

On your first space trip, you land on a planet. You are curious about its acceleration due to gravity and remembering your Physics 101 class you take along a spring, meter stick, 300 gram mass and stop watch. You measure the time for 10 oscillations of the 300 gram mass to be 12.0 s and ~~the~~ extension of the spring to be 25 cm.

(1) $T = \frac{12.0\,s}{10} = \boxed{1.20\,s}$

i) What is the spring constant of your spring?

(1) $K = m\omega^2 = (0.300\,kg)\left(\frac{2\pi}{1.2\,s}\right)^2 = \boxed{8.22\,\frac{N}{m}}$

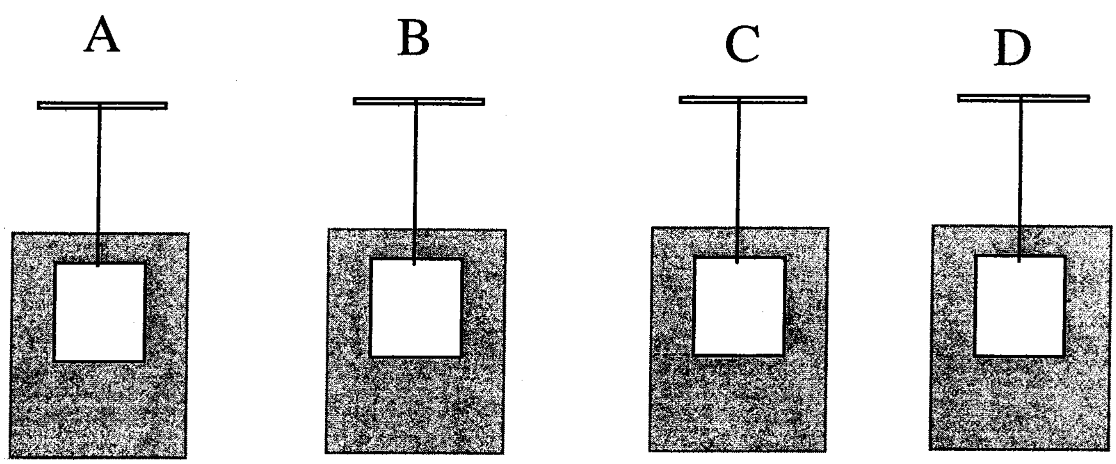
ii) What is the acceleration due to gravity on the planet?

$mg = kx$ equil pos'n

(1) $g = \frac{kx}{m} = \frac{8.22 \times 0.25}{0.300} = \boxed{6.85\,m/s^2}$

(2) **Question 4 b**

Four different blocks are hung inside identical containers of water. The blocks have different masses and volumes but all would sink in the fluid if the strings were cut



A	B	C	D
M_A=150 g	M_B=250 g	M_C=200 g	M_D=150 g
V_A= 25 cm^3	V_B= 100 cm^3	V_C= 40 cm^3	V_D= 50 cm^3
mass water disp: 25g	100g	40g	50g

i) Rank the buoyant force acting on each object

→ largest volume ... smallest volume

Greatest Buoyant force ... Least Buoyant force

(1) $\boxed{B > D > C > A}$

iii) Rank the blocks on the basis of the tension in the strings holding the blocks

(M_A − mass water displaced) A = 125 g, B = 150 g, C = 160 g, D = 100 g

Greatest Tension ... Least Tension

(1) $\boxed{C > B > A > D}$