Family name: ______________________

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Student ID: ______________________

University of Technology, Sydney

THIS PAPER MUST NOT BE REMOVED FROM THE EXAMINATION CENTRE

AUTUMN SEMESTER EXAMINATION, 2012
FACULTY OF SCIENCE

SUBJECT NAME: Foundations of Physics

SUBJECT NO.: 68101

DAY/DATE: Tuesday 12th June, 2012

TIME ALLOWED: 2 hours + 10 minutes optional reading time

START/END TIME: 2:00 – 4:10 pm

Instructions to Candidates:

This paper was designed to be completed in 2 hours. An extra 10 minutes have been added to the time allowed and it is recommended that you use this time to read the paper before commencing to answer the questions.

THERE ARE 4 QUESTIONS IN THIS PAPER.

ATTEMPT ALL QUESTIONS

ANSWER EACH QUESTION IN A SEPARATE BOOKLET

CLEARLY MARK THE QUESTION NUMBER ON THE FRONT OF EACH BOOKLET

Calculators may be used.

Formula sheets are provided on pages 7–8 of the examination paper

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Question 1 (20 marks)

[5] (a) A motorist checks the air pressure of one of his tyres after driving at high speed, obtaining a reading of 300 kPa on a pressure gauge. He notices that the temperature of the tyre is 50 °C.

What will be the pressure when the tyre returns to the ambient air temperature of 20 °C? You may assume the volume of the tyre remains constant.

[5] (b) Calculate the mass of 1.0 m^3 of air at an absolute pressure of 101.3 kPa and a temperature of 17 °C.

[5] (c) Compute the average translational kinetic energy of a molecule of a gas at room temperature (300 K).

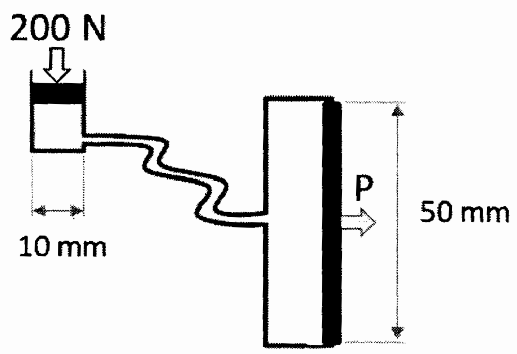
[5] (d) Assuming the gas in part (c) above is H_2, calculate the rms velocity of a single molecule.

Data:–

$$\text{Atmospheric pressure, } P_{\text{atm}} = 101.3\,\text{kPa}$$
$$\text{Molecular weight of air, } M_{\text{air}} = 0.029\,\text{kg/mol}$$
$$\text{Universal gas constant, } R = 8.314\,\text{J/(mol K)}$$
$$\text{Boltzmann's constant, } k = 1.38 \times 10^{-23}\,\text{J/K}$$
$$\text{Mass of } H_2 \text{ molecule, } M_{\text{H}} = 3.32 \times 10^{-27}\,\text{kg}$$

Question 2 (20 marks)

[5] (a) A force of 200 N is applied to a car's braking system master cylinder, which has a diameter of 10 mm, as shown below. What force is applied to the brake disc if the diameter of the slave piston which bears on the disk is 50 mm?



[5] (b) A cork fishing float is observed to be floating in still water with two thirds of its volume showing above the surface. Determine the density of the cork.

Data:–

$$\text{Density of water, } \rho_{\text{water}} = 1\,000\,\text{kg/m}^3$$

Q2 continues on next page ...

[5] (c) An airship has a volume of 1 000 m^3 and is filled with helium gas of density 0.18 kg/m^3. Calculate the maximum mass that it can lift i.e. the combined mass of the airship frame, the cabin and the payload.

Data:–

$$\text{Density of air, } \rho_{air} = 1.29\,kg/m^3$$

(d) A wind of velocity 160 km/h is blowing over the top of the flat roof of a house.

[4] i. Calculate the difference in air pressure on the outside compared to the inside, given the density of air to be 1.3 kg/m^3.

[1] ii. State whether the air pressure inside the house is greater than or less than the air pressure outside.

Question 3 (20 marks)

(a) Many oscillating systems can be described quite well by what we call Simple Harmonic Motion (SHM).

[1] i. What characteristic of an oscillating physical system determines whether it oscillates in a manner that can be described as SHM?

[1] ii. Draw a diagram that depicts how the displacement from equilibrium varies with time when an object executes SHM.

[2] iii. Label the diagram to show the period and amplitude.

[2] iv. Indicate the points on the diagram where the maxima of kinetic and potential energy occur.

(b) A body of mass 0.50 kg is executing simple harmonic motion around a central equilibrium position. When the displacement is 0.05 m, the restoring force is 0.5 N

[2] i. Find the period of the motion.

[3] ii. Calculate the maximum kinetic energy of the body.

(c) While tuning a guitar string against a calibration frequency, a player hears a series of 'beats' when the string is nearly in tune.

[2] i. Why do these beats occur?

[3] ii. Explain in detail what the guitarist hears and how what she hears relates to the frequency of vibration of the string and the calibration frequency.

(d) Assuming that the frequency of the note being played on the guitar in part (c) is 1 000 Hz and the velocity of the wave along the string is 500 m/s:

[2] i. What is the active length of the guitar string being plucked?

[2] ii. What will be the wavelength in air of the resulting sound wave?

Question 4 (20 marks)

[2] (a) With the aid of a diagram, describe the field of view experienced by an underwater observer of activity above the water surface. What is the nature of this fish-eye view?

[3] (b) Real lenses (such as the ones shown in the lectures) are very much more complex than the simple concave and convex lenses used in demonstrations. Discuss briefly some of the reasons that manufacturers produce very complex lens designs.

(c) An object of height 10 mm is placed 25 cm in front of a concave lens with focal length of 40 cm.

[2] i. Sketch a ray diagram showing the object, lens and image.

[2] ii. Determine the image distance.

[2] iii. Determine the height of the image.

[1] iv. Is the image real or virtual?

(d) A telescope is used in astronomy to observe distant objects.

[3] i. Draw a diagram of an 'astronomical' telescope showing the relationship of the focal lengths, the length of the instrument and type of lenses involved.

[2] ii. Add schematic rays to your diagram that show how light is propagated through the instrument.

[1] iii. Explain why this device is unsuited to terrestrial purposes (e.g. searching for land on the horizon from a ship).

[2] iv. Discuss the character of the image formed by this telescope and explain how magnification is defined in this instrument.

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Thermal Equations

$\Delta L = L_0 \alpha \Delta T$ $\Delta V = V_0 \beta \Delta T$ $\Delta A = 2\alpha A \Delta T$ $\Delta V = 3\alpha V_0 \Delta T$

$\Delta Q = mc\Delta T$ $Q = nC\Delta T$ $Q = mL$

$P = \frac{dQ}{dt} = -kA\frac{dT}{dx}$ $P = -hA\Delta T$

$P = \sigma \varepsilon A T^4$ $P = \sigma \varepsilon A \left(T^4 - T_0^4\right)$ $\frac{dQ}{dt} = \frac{\Delta T}{R}$

$R = \frac{L}{k}$ $\frac{dT}{dt} = -k(T_0 - T_S)$ $N = nN_A$

$pV = nRT$ $pV = NkT$ $pV^\gamma = \text{cons.}$ $TV^{\gamma-1} = \text{const.}$ $n = \frac{m}{M}$

$pV = \frac{Nm\overline{v^2}}{3}$ $\frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$ $v_{\text{rms}} = \sqrt{\frac{3kT}{m}}$ $v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

$P = -qA(T - T_S)$ $C_p - C_v = R$

$$C_v = \begin{cases} \frac{3}{2}R & \text{(mono)} \\ \frac{5}{2}R & \text{(di)} \\ \frac{6}{2}R & \text{(poly)} \end{cases}$$

$\gamma = \frac{C_p}{C_v}$

$\Delta E_{\text{int}} = Q - W$ $\Delta E_{\text{int}} = nC_v\Delta T$ $W = \int_{V_i}^{V_f} p\,dV$

Waves / Optics Equations

$F = -kx$	$a = -\omega^2 x$	$\omega = \sqrt{\frac{k}{m}}$
$\omega = 2\pi f$	$x = A\cos(\omega t + \alpha)$	$U = \frac{1}{2}kx^2$
$T = \frac{2\pi}{\omega}$	$T = 2\pi\sqrt{\frac{\ell}{g}}$	$T = 2\pi\sqrt{\frac{m}{k}}$
$y = A\sin(kx - \omega t + \phi)$	$v = f\lambda \qquad k = \frac{2\pi}{\lambda}$	$v = \sqrt{\frac{F}{\mu}}$
$y = 2A\sin(kx)\cos(\omega t)$	$v = \sqrt{\frac{\gamma P}{\rho}}$	$v = \frac{\omega}{k}$
$v_{\text{max}} = \omega A$	$P = 2\pi^2 \mu v A^2 f^2$	$I = 2\pi^2 \rho v A^2 f^2$
$n_1 \sin\theta_1 = n_2 \sin\theta_2$	$n = \frac{c}{v}$	$n_1 v_1 = n_2 v_2$
$d_{\text{app}} = \frac{d}{n}$	$\beta = 10\log_{10}\frac{I}{I_0}$	$I = \frac{P}{A}$
$\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$	$m = -\frac{i}{p}$	$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$
$m_\theta = -\frac{f_o}{f_e}$	$d = f_o + f_e$	$m_\theta = \frac{250}{f}$
$d\sin\theta = m\lambda$	$a\sin\theta = m\lambda$	$a\sin\theta = 1.22\lambda$

Properties of Matter / Fluids Equations

$p = p_0 + \rho g y$	$p + \frac{1}{2}\rho v^2 + \rho g y = \text{const.}$	$v = \sqrt{2gy}$
$R_V = Av = \text{const.}$	$F_g = m_F g$	$F = \rho V g$

END OF EXAMINATION PAPER