Cover Type A

UNIVERSITY OF TECHNOLOGY SYDNEY

THIS PAPER MAY BE REMOVED FROM THE EXAMINATION CENTRE

AUTUMN SEMESTER EXAMINATION, 2004
FACULTY OF SCIENCE

SUBJECT NAME: Foundations of Physics

SUBJECT NUMBER: 68101

DAY/DATE: Friday 18th June, 2004

TIME ALLOWED: 3 hours + 10 minutes reading time

START/END TIME: 2:00 pm – 5:10 pm

Instructions to Candidates:

This paper was designed to be completed in 3 hours. An extra 10 minutes have been added to the time allowed and it is recommended that you use these 10 minutes to read the paper before commencing to answer the questions.

ATTEMPT QUESTION 1 AND ANY OTHER FIVE (5) QUESTIONS

ANSWER EACH QUESTION IN A SEPARATE BOOKLET

CLEARLY MARK THE QUESTION NUMBER ON THE FRONT OF EACH BOOKLET

Calculators may be used. Any text or formulae stored in your calculator must have been removed before entering the examination room.

A *Physics Data Sheet* is provided on the next page.

Formula sheets and graph paper are provided at the end of the examination paper.

Physics Data Sheet

$$
\begin{aligned}
g &= 9.81\ \mathrm{m\cdot s^{-2}} \\
\sigma &= 5.670\times10^{-8}\ \mathrm{W\cdot m^{-2}\,K^{-4}} \\
R &= 8.314\ \mathrm{J\ mole^{-1}\,K^{-1}} \\
N_0 &= 6.022\times10^{23}\ \mathrm{molecules\cdot mole^{-1}} \\
k &= 1.381\times10^{-23}\ \mathrm{J\cdot K^{-1}\ molecule^{-1}} \\
c &= 2.998\times10^{8}\ \mathrm{m\cdot s^{-1}} \\
h &= 6.626\times10^{-34}\ \mathrm{J\cdot s} \\
\varepsilon_0 &= 8.854\times10^{-12}\ \mathrm{F\cdot m^{-1}} \\
\mu_0 &= 4\pi\times10^{-7}\ \mathrm{H\cdot m^{-1}} \\
e &= 1.602\times10^{-19}\ \mathrm{C} \\
m_e &= 9.110\times10^{-31}\ \mathrm{kg} \\
&= 0.00055\ \mathrm{u} \\
m_p &= 1.673\times10^{-27}\ \mathrm{kg} \\
&= 1.00728\ \mathrm{u} \\
m_n &= 1.675\times10^{-27}\ \mathrm{kg} \\
&= 1.00866\ \mathrm{u} \\
1\mathrm{u} &= 1.661\times10^{-27}\ \mathrm{kg} \\
G &= 6.673\times10^{-11}\ \mathrm{m^2\,N\cdot kg^{-2}} \\
\text{Rydberg's constant} &= 1.097\times10^{7}\ \mathrm{m^{-1}} \\
\text{Temperature of Ice Point} &= 273.15\ \mathrm{K} \\
\text{1 atmosphere} &= 1.013\times10^{5}\ \mathrm{Pa} \\
\text{Mass of Earth} &= 5.974\times10^{24}\ \mathrm{kg} \\
\text{Radius of Earth} &= 6.37\times10^{6}\ \mathrm{m} \\
\text{1 Curie} &= 3.70\times10^{10}\ \text{becquerel}
\end{aligned}
$$

SECTION A

(To be answered in a separate booklet)
THIS QUESTION IS COMPULSORY

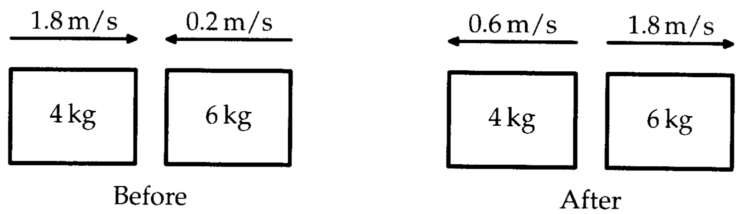
Question 1 (30 marks)

(a) Write the answers to the following multiple choice questions in your examination booklet. Show all working where appropriate.

i. Which *one* of the following situations is impossible?

A. An object has zero velocity but non-zero acceleration.
B. An object has constant non-zero acceleration and changing velocity.
C. An object has constant non-zero velocity and changing acceleration.
D. An object has velocity directed east and acceleration directed east.
E. An object has velocity directed east and acceleration directed west. [$1\frac{1}{2}$]

ii. Which *one* of the following options best describes the nature of the collision shown in the diagram below? The masses of the blocks, and their velocities before and after the collision are indicated.



The collision is:

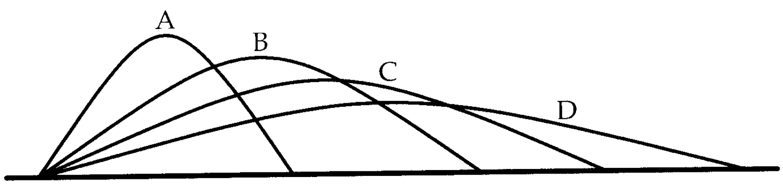
A. inelastic
B. explosive
C. characterized by an increase in kinetic energy
D. perfectly elastic
E. not possible because momentum is not conserved. [$1\frac{1}{2}$]

Q1 continues on next page ...

iii. Consider a brick that is totally immersed in water. The long edge of the brick is vertical. The pressure on the brick is

A. greatest on the face with largest area.
B. greatest on the bottom of the brick.
C. greatest on the top of the brick.
D. greatest on the sides of the brick.
E. the same on all surfaces of the brick. [$1\frac{1}{2}$]

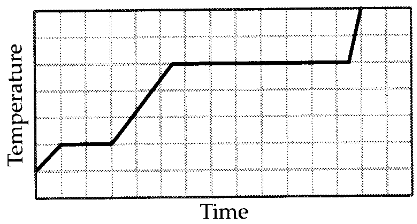
iv. The trajectories of four artillery shells are shown in the diagram below.



Each shell was fired with the same speed. Which was in the air the longest time?

A. A
B. B
C. C
D. D
E. All were in the air for the same time. [$1\frac{1}{2}$]

v. Heat is added to a pure substance in a closed container at a constant rate. A graph of the temperature of the substance as a function of time is shown below.



If LF is the latent heat of fusion and LV is the latent heat of vaporization, what is the value of the ratio LV/LF for this substance?

A. 1.5
B. 5.0
C. 4.5
D. 7.2
E. 3.5 [$1\frac{1}{2}$]

Q1 continues on next page . . .

vi. The Bernoulli effect is responsible for the lift force on an aeroplane wing. Wings must therefore be designed so as to ensure that

A. wings are thick enough to create a significant pressure difference between the top and bottom surfaces of the wings because of the different heights of these surfaces.

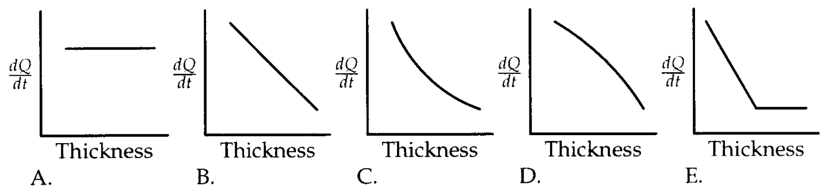
B. air molecules will be deflected downward when they hit the wing.

C. air molecules will be deflected upward when they hit the wing.

D. air molecules move more rapidly past the upper surface of the wing than past the lower surface.

E. air molecules move more rapidly past the lower surface of the wing than past the upper surface. [$1\frac{1}{2}$]

vii. An architect is interested in estimating the heat loss through a sheet of insulating material as a function of the thickness of the sheet. Assuming fixed temperatures on the two faces of the sheet, which of the following graphs best represents the heat transfer as a function of the thickness of the insulating sheet?



[$1\frac{1}{2}$]

viii. Suppose you put your face in front of a concave mirror. Which *one* of the following choices is true?

A. No matter where you place yourself, a real image will be formed.

B. If you position yourself between the center of curvature and the focal point of the mirror, you will not be able to see your image.

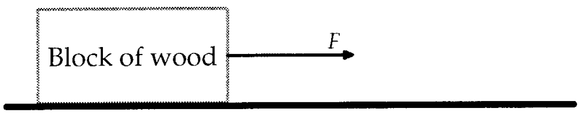
C. Your image will be diminished in size.

D. Your image will always be inverted.

E. None of these is true. [$1\frac{1}{2}$]

Q1 continues on next page ...

(b) In an experiment to study the frictional forces between bodies, a group of Physics students applied a force to a block of wood resting on a flat metal surface as shown below.



It was found that the *minimum* force F required to start the block moving increases as extra masses are placed on top of the block. The students postulated that the relation between the total mass m and F is linear i.e. $F = km$, where k is a constant.

Their results are tabulated below.

Reading	$m \pm 0.05$ kg	$F \pm 0.2$ (N)
1	0.52	3.1
2	0.58	3.6
3	0.64	3.9
4	0.75	4.4
5	0.88	5.2
6	1.01	6.2
7	1.21	7.4

In this table, m is the mass of the loaded block, and F is the minimum force required to move it.

i. Describe an experimental arrangement the students may have used to apply F. (A sketch may be useful.) [1]

ii. Using *one* of the m values and the corresponding F value from your table, estimate the value of k (it is not necessary to calculate the uncertainty in this value). [1]

iii. The students now decide to use a graphical method to find k, rather than a simple calculation as in part (ii). Why is it better to use a graph? [1]

iv. Tear off the sheet of graph paper provided at the end of this examination paper, and on it plot F versus m (with error bars). Comment on the validity of the students' hypothesis.
(Don't forget to write your name on the graph paper and to include it inside your Q1 answer booklet.) [6]

v. Using the graph, estimate the coefficient of (static) friction, μ_s, between the block and the metal surface, and its uncertainty. [3]

(c) During the semester you have watched a video showing the historical development of astronomy in Australia, acknowleded to be at the forefront in this field. In about a page of writing, describe some highlights of the video, including at least two natural advantages Australia has for making observations, and two of its past or current strengths in astronomy. [5]

SECTION B

Answer any five (5) questions from this section

EACH QUESTION MUST BE ANSWERED IN A SEPARATE BOOKLET

Question 2 (30 marks)

(a) A 0.12 kg ball is thrown vertically upwards, reaches a height of 4.5 m and then falls.

i. Calculate the initial speed of the ball. [2]

ii. Calculate the time it takes for the ball to reach its maximum height. [2]

iii. Calculate the kinetic energy of the ball when it is 2.5 m above its starting position. [3]

(b) An aeroplane pilot sets a compass course due west and maintains an airspeed of 220 km/h. After flying for 30 minutes, the aeroplane is over a town that is 150 km west and 40 km south of its starting point.
Let $\hat{\mathbf{i}}$ be a unit vector due East, and $\hat{\mathbf{j}}$ a unit vector due North. Let $\vec{\mathbf{v}}_{\text{pa}}$ be the plane's velocity relative to the air, and let $\vec{\mathbf{v}}_{\text{pg}}$ be its velocity relative to the ground.

i. Express $\vec{\mathbf{v}}_{\text{pg}}$ in terms of $\hat{\mathbf{i}}$ and $\hat{j}$. (**Hint**: A diagram may help!) [2]

ii. Express $\vec{\mathbf{v}}_{\text{pa}}$ in terms of $\hat{\mathbf{i}}$ and $\hat{\mathbf{j}}$. [2]

iii. Hence, determine the wind speed $\vec{\mathbf{v}}_{\text{ag}}$ in terms of $\hat{\mathbf{i}}$ and $\hat{\mathbf{j}}$. [3]

iv. Calculate the magnitude and direction of the wind. [2]

(c) An arrow is shot into the air at an angle of 45° above the horizontal, with a velocity $\vec{v}$ m/s. The arrow hits an apple tree a horizontal distance $D = 220$ m away, at the same height above the ground as it was shot.

i. Write down the horizontal and vertical components, v_x and v_y (respectively), of the arrow's initial velocity, $\vec{v}$. [3]

ii. Determine t_a, the time that the arrow spends in the air before hitting the tree. [3]

iii. Suppose a ripe apple falls from a vertical distance 4 m directly above the point where the arrow hits the tree, and is impaled by the arrow on the tree.
How long after the arrow was shot did the apple drop? [3]

(d) The excess pressure, Δp, at the centre of a soap bubble is experimentally found to depend only on the radius of the bubble, R, and the surface tension, γ (a quantity whose units are those of force per unit length).
Using the 'method of dimensions', suggest the relationship which might exist between these quantities. Show all working. [5]

Question 3 (30 marks)

(a) State Newton's first law, and give two examples of its occurrence in everyday life. [3]

(b) A 6 kg bucket of water is being pulled straight up by a ('massless') cord. The upward acceleration of the bucket is constant, with magnitude $3\,\mathrm{m/s^2}$.

i. What is the weight of the bucket of water? [1]

ii. What force (magnitude and direction) does the cord exert on the bucket? [2]

iii. What is the tension in the cord? [2]

iv. If the cord can sustain a maximum load of 9 kg, what is the maximum upward acceleration this bucket of water can be given? [2]

(c) Jane and her son Peter, whose combined mass is 85 kg, sit on toboggan (sled) on a long, snow-covered hillside. The coefficient of kinetic friction between the toboggan and snow is $\mu_k = 0.10$. The slope of the hill is just right to make their toboggan slide at a constant velocity.

i. Draw a free-body diagram of the toboggan (with its two passengers) in motion. [3]

ii. What is the slope, α, of the hill? [3]

iii. How much heat is generated through friction by the toboggan in the first 20 m? [2]

iv. Suppose Peter falls off the toboggan, but Jane stays on board. How does the toboggan's motion change? Justify your answer. [2]

(d) An amusement park ride consists of a cylindrical room that rotates about its vertical axis. At a certain rotation speed, a person against the wall can pick his or her feet off the floor and remain 'stuck' to the wall without falling. Suppose the rotation results in a person of mass m having speed v. The radius of the room is R, and the coefficient of static friction between the person and the wall is μ_s.

i. Briefly explain how this ride works, using a free-body diagram to support your answer. [3]

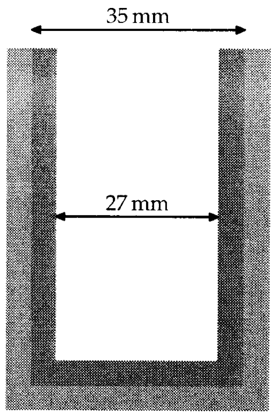
ii. Deduce an equation for the minimum speed v_0 required for such a ride. [4]

iii. Suppose Jason and Natalie are on the ride. Jason is wearing denim ($\mu_s = 0.50$), and Natalie is wearing polyester ($\mu_s = 0.10$). The ride starts from rest and as it speeds up Natalie finds she must wait longer than Jason before being able to raise her feet without sliding to the floor. What is the ratio of speeds, $V_J : V_N$, at which Jason and Natalie can first lift their feet without sliding down? [3]

Question 4 (30 marks)

(a) A cylindrical drinking glass is placed inside another cylindrical glass, as shown below. When both are at room temperature (20°C) the two just fit, because the outer radius (35mm) of the inside glass is equal to the inner radius of the outside glass. The wall thickness of each glass is 4 mm.

The inside glass is then filled with cold water at 5°C, while the outside glass is heated to 45°C by running hot water over it.



Assuming the inner glass material is all at the lower temperature and the outer glass material is all at the higher temperature, determine the separation distance between the two glasses.

Data:

$$\alpha_{\text{glass}} = 8.5 \times 10^{-6}\,\text{K}^{-1}$$
$$\beta_{\text{glass}} = 26 \times 10^{-6}\,\text{K}^{-1}$$

[6]

(b) Cold water at a temperature of 15°C enters a heater and the resulting hot water has a temperature of 61°C. A person uses 120 kg of hot water in taking a shower.

i. Find the energy needed to heat the water. [2]

ii. Assuming that the electricity charges are 10 cents per kilowatt-hour, determine the cost of heating the water. [3]

Data:

$$C_{\text{water}} = 4\,186\,\text{J} \cdot \text{kg}^{-1}\text{K}^{-1}$$

Q4 continues on next page ...

(c) A 40 g block of ice is cooled to $-78°C$. It is added to 560 g of water in an 80 g copper calorimeter at a temperature of $25°C$. Determine the final temperature, *or*, if all the ice does not melt, determine how much ice is left. [8]

Data:

$$C_{\text{ice}} = 2\,110\,\text{J}\cdot\text{kg}^{-1}\text{K}^{-1}$$
$$C_{\text{water}} = 4\,186\,\text{J}\cdot\text{kg}^{-1}\text{K}^{-1}$$
$$C_{\text{Cu}} = 400\,\text{J}\cdot\text{kg}^{-1}\text{K}^{-1}$$
$$L_{\text{ice-water}} = 3.35\times 10^{5}\,\text{J/kg}$$

(d) The supergiant star Betelgeuse has a surface temperature of about 2 900 K and emits a radiant power of approximately 4×10^{30} W. Assuming that Betelgeuse is a perfect emitter ($e = 1$) and spherical, find its radius. [6]

(e) If you were stranded in mountainous country in the middle of winter, it would help to minimize energy losses from your body by curling up into the tightest ball possible.

i. By doing this are you reducing heat losses by conduction or by radiation? [1]

ii. Explain, using the appropriate heat transfer equation, which terms are being controlled by this action. [4]

Question 5 (30 marks)

(a) i. Describe what is meant by the 'Kinetic Theory of Gases', including the overall assumptions made about the particles making up the gas, and the major findings of the theory. [3]

ii. Initially the translational rms speed of a molecule of an ideal gas is 463 m/s. The pressure and volume of this gas are kept constant, while the number of molecules is doubled. Use the kinetic theory to determine the final translational rms speed of the molecules. [4]

(b) In a diesel engine, the piston compresses air at 305 K to a volume that is one-sixteenth of the original volume and a pressure that is 48.5 times the original pressure.

i. What is the temperature of the air after the compression? [4]

ii. Show these changes on an appropriately labelled p-V diagram. [4]

(c) The spring constant for a spring in a dart gun is 1400 N/m. When the gun is cocked, the spring is compressed by 0.075 m.
What is the speed of a 2.4×10^{-2} kg dart when it leaves the gun horizontally? [7]

(d) A wave has a displacement (in metres) of

$$y = 0.45 \sin(8.0\pi t + \pi x)$$

where t and x are expressed in seconds and metres, respectively. For this wave, find:

i. the amplitude [1]

ii. the frequency [1]

iii. the wavelength [1]

iv. the speed [2]

v. the direction of travel. [1]

vi. the maximum velocity of a particle in the wave. [2]

Question 6 (30 marks)

(a) At a distance of 3.8 metres from a siren, the sound intensity is $3.6\,\mathrm{W/m^2}$.

i. Assuming it radiates sound uniformly in all directions, find the total power radiated by the siren. [2]

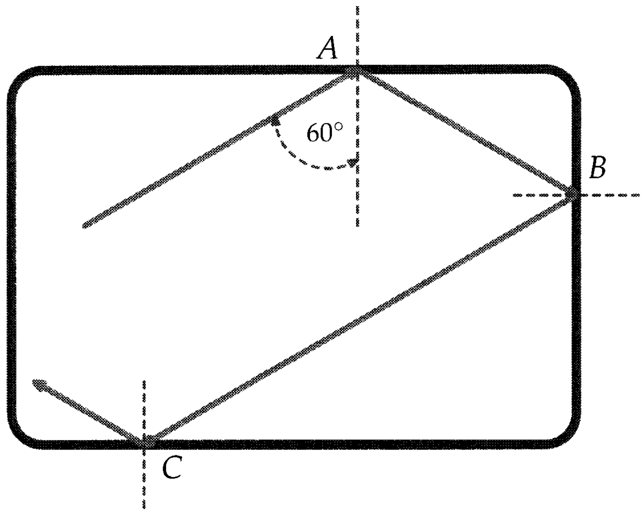
A particular observer's ears are troubled by sounds greater than 90 dB.

ii. What is the sound intensity in dB at 3.8 m? [2]

iii. To what distance should the observer move to reduce the sound to a comfortable level for him? [3]

(b) State Snell's law, sketching a diagram of an interface between two materials to identify the symbols used in the law. [4]

(c) The drawing below shows a crown glass slab with a rectangular cross section. The dashed lines at A, B and C are normals to the glass surface.



As illustrated, a laser beam strikes the upper surface at an angle of 60.0°. After reflecting from the upper surface, the beam reflects from the side and bottom surfaces.

i. If the glass has RI = 1.50 and is surrounded by air (RI = 1.00), determine where part of the beam first exits the glass, at point A, B or C? [3]

ii. Repeat the above calculations with the glass surrounded by water (RI = 1.33) instead of air. [3]

Q6 continues on next page ...

(d) Describe the 'electromagnetic spectrum', indicating the range of frequencies/wavelengths covered by the various regions of the spectrum. [4]

(e) A refracting telescope has an objective and an eyepiece that have refractive powers of 1.25 dioptres and 250 dioptres, respectively.

i. What are the focal lengths of each lens? [2]

ii. What is the angular magnification of the telescope? [2]

iii. What is the length of the telescope? [1]

iv. Sketch the setup of the telescope using the two lenses, indicating any relevant distances on the diagram. [3]

Question 7 (30 marks)

(a) i. It is about 2 200 years since Archimedes developed what is now known as Archimedes' Principle.
State this principle, and briefly give an example of its application in everyday life. [2]

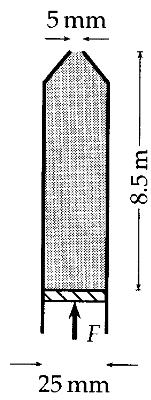
ii. A balloon weighing 80 kg has a capacity of 1 200 m^3 of gas.
If it is filled with helium, what is the maximum load (in kilograms) the balloon can support? [2]

Data:

$$\text{Density of helium} = 0.18\,\text{kg/m}^3$$
$$\text{Density of air} = 1.30\,\text{kg/m}^3$$

iii. What difference would it make to your answer in part (ii) above if this flight were attempted on the moon, where there is no atmosphere and g is about one-sixth of that on earth? [1]

(b) A fire protection system for a house includes a pump that drives water (density $10^3\,\text{kg}\cdot\text{m}^{-3}$) up a vertical pipe of diameter 25 mm and length 8.5 m to the roof. The top of the pipe is fitted with a nozzle of diameter 5 mm. The action of the pump is modelled by a piston pushed by a steady force F. The setup is shown below in cross-section. It is not drawn to scale.



It is required that the pump propels water 3.5 m above the nozzle.

i. What must be the speed with which water moves through the nozzle? [2]

ii. Given the speed through the nozzle you obtained in part i, what must be the speed of the piston? [2]

iii. Given the speed of the piston you obtained in part ii, find the force exerted by the piston. State all assumptions made. [4]

Q7 continues on next page ...

(c) A 45.0 m long nylon rope used by a mountain climber stretches 1.10 m under the weight of a 65.0 kg climber. The diameter of the rope is 7 mm.

i. Calculate the stress in the rope when supporting this climber. [2]

ii. Calculate the corresponding strain in the rope. [2]

iii. What is Young's modulus for the rope? [1]

(d) i. State Bernoulli's equation, and explain the meaning of any symbols appearing in it. [3]

ii. The level of water in a large tank is 12 m above a very small hole in the side of the tank.
Calculate the speed of water leaving the tank through this hole. [5]

(e) Use Poiseuille's equation to calculate the time taken for blood to pass through a 1.0 mm long and 6 μm diameter capillary of the human circulation system, if the pressure difference between its ends is 2.80 kPa. The viscosity of blood is 4.0×10^{-3} Pa·s. [4]

Mechanics Equation Sheet

$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M = 0$$
$$F = ma$$
$$F = \mu N$$
$$F = -ks$$
$$W = Fs$$
$$W = \int \mathbf{F} \cdot d\mathbf{s}$$
$$P = Fv$$
$$KE = \tfrac{1}{2}mv^2$$
$$p = mv$$
$$J = Ft$$
$$J = \int F dt$$

$$\mathbf{v}_{ac} = \mathbf{v}_{ab} + \mathbf{v}_{bc}$$
$$s = ut + \tfrac{1}{2}at^2$$
$$v = u + at$$
$$v^2 = u^2 + 2as$$
$$c^2 = a^2 + b^2 - 2ab\cos C$$
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$
$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$
$$W = -\tfrac{1}{2}ks^2$$

$$\theta = \omega_0 t + \tfrac{1}{2}\alpha t^2$$
$$\omega = \omega_0 + \alpha t$$
$$\omega^2 = \omega_0^2 + 2\alpha\theta$$
$$s = R\theta$$
$$v = R\omega$$
$$a = R\alpha$$
$$a_n = \frac{v^2}{R} = \omega^2 R$$
$$T = Fr$$

Solid cylinder $I_C = \frac{1}{2}MR^2$

Hollow cylinder $I_C = \frac{1}{2}M(R^2 + r^2)$

Sphere $I_C = \frac{2}{5}MR^2$

Rod $I_C = \frac{1}{12}Ml^2$

$$L = I\omega$$
$$\Delta L = T\Delta t$$
$$W = T\theta$$
$$KE = \tfrac{1}{2}I\omega^2$$
$$P = T\omega$$

Thermal Equation Sheet

$$\Delta l = l_0 \alpha \Delta T \qquad \Delta V = V_0 \beta \Delta T$$

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

$$H = \frac{dQ}{dt} = -kA\frac{dT}{dx} \qquad H = \frac{dQ}{dt} = -e\sigma A\left(T^4 - T_0^4\right) \qquad \frac{dQ}{dt} = \frac{\Delta T}{R}$$

$$PV = nRT \qquad PV = NkT \qquad PV^\gamma = const.$$

$$PV = \frac{Nm\overline{v^2}}{3} \qquad \tfrac{1}{2}m\overline{v^2} = \tfrac{3}{2}kT \qquad H = -qA(T - T_S)$$

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

$$Q = W + \Delta U \qquad \Delta U = nC_v\Delta T \qquad W = P\left(V_f - V_i\right)$$

$$W = \frac{P_i V_i - P_f V_f}{\gamma - 1} \qquad W = nRT\ln\left(\frac{V_f}{V_i}\right)$$

$$\frac{Q_1}{Q_2} = \frac{T_1}{T_2} \qquad e = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1} \qquad \text{C.O.P.} = \frac{Q}{W} = \frac{T_2}{T_1 - T_2}$$

Waves / Optics Equation Sheet

$F = -kx$ $\qquad T = 2\pi\sqrt{\frac{l}{g}}$ $\qquad \omega^2 = \frac{k}{m}$

$U = \frac{1}{2}kx^2$ $\qquad x = A\sin(\omega t + \alpha)$

$y = A\sin(kx - \omega t + \phi)$ $\qquad y = 2A\sin kx\cos\omega t$

$c = f\lambda$ $\qquad c = \sqrt{\frac{F}{\mu}}$

$n_1\sin i = n_2\sin r$ $\qquad n_1c_1 = n_2c_2$ $\qquad d_a = \frac{d}{n}$

$P = 2\pi^2A^2f^2\mu c$ $\qquad I = 2\pi^2A^2f^2\rho c$

$c = \sqrt{\frac{\gamma P}{\rho}}$

$\beta = 10\log_{10}\left(\frac{I}{I_0}\right)$

$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$ $\qquad \frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ $\qquad m = -\frac{i}{o}$

$d\sin\theta = m\lambda$ $\qquad a\sin\theta = m\lambda$ $\qquad a\sin\theta = 1.22\lambda$

$m_l = \frac{250}{f} + 1$ $\qquad \alpha = \frac{\pi a\sin\theta}{\lambda}$ $\qquad \beta = \frac{\pi d\sin\theta}{\lambda}$

$I = \frac{I_{\text{max}}\sin^2\alpha\cos^2\beta}{\alpha^2}$ $\qquad I = I_0\cos^2\theta$

$m_\theta = \frac{f_o}{f_e}$ $\qquad R = \frac{\lambda}{\Delta\lambda} = mN$ $\qquad D = \frac{d\theta}{d\lambda}$

$$\sin A + \sin B = 2\sin\left(\frac{A+B}{2}\right)\cos\left(\frac{A-B}{2}\right)$$

Properties of Matter / Fluids Equation Sheet

$$Y = \frac{F/A}{\Delta l / l_0} \qquad B = \frac{-\Delta p}{\Delta V / V_0} \qquad S = \frac{F/A}{d/y} \qquad \sigma = \frac{-\Delta b / b_0}{\Delta l / l_0}$$

$$p = p_0 + \rho g h \qquad p + \tfrac{1}{2}\rho v^2 + \rho g y = \text{const.} \qquad v = \sqrt{2gh}$$

$$\gamma = \frac{F}{l} = \frac{W}{\Delta A} \qquad h = \frac{2\gamma \cos\theta}{\rho g R} \qquad \Delta p = \frac{2\gamma}{R} \text{ or } \frac{4\gamma}{R}$$

$$Q = Av = \text{ const.} \qquad Q = \frac{\pi R^4 \Delta p}{8\eta l} \qquad v_1^2 = \frac{2(p_1 - p_2)}{\rho\left[\left(\frac{A_1}{A_2}\right)^2 - 1\right]}$$

$$\eta = \frac{F/A}{\Delta v / \Delta y} \qquad F = 6\pi\eta R v$$

$$N_R = \frac{\rho v D}{\eta} \qquad v_t = \frac{2r^2 g(\rho_s - \rho_f)}{9\eta}$$

Electricity and Magnetism Equation Sheet

$$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} \qquad V = \frac{q}{4\pi\varepsilon_0 r} \qquad E = \frac{q}{4\pi\varepsilon_0 r^2}$$

$$U = \frac{q_1 q_2}{4\pi\varepsilon_0 r} \qquad E = -\frac{dV}{dx}$$

$$C = \frac{\varepsilon_0 A}{d} \qquad U_E = \tfrac{1}{2}CV^2 \qquad W = \tfrac{1}{2}QV$$

$$W = VIt \qquad R = \rho\frac{l}{A} \qquad R_T = R_0\left[1 + \alpha(T - T_0)\right]$$

$$V = IR \qquad P = VI$$

$$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q}{\varepsilon_0} \qquad \mathbf{F} = q\mathbf{v} \times \mathbf{B} \qquad \mathbf{F} = i\mathbf{l} \times \mathbf{B}$$

$$\mathbf{M} = i\mathbf{A} \qquad \mathbf{\Gamma} = \mathbf{M} \times \mathbf{B} \qquad \frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi a}$$

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I \qquad dB = \frac{\mu_0 i dl \sin\theta}{4\pi r^2} \qquad \phi_B = \int \mathbf{B} \cdot d\mathbf{A}$$

$$\varepsilon = -\frac{d}{dt}(N\phi_B) \qquad \varepsilon = -L\frac{di}{dt} \qquad \varepsilon = -M\frac{di}{dt}$$

$$U_B = \frac{1}{2}Li^2 \qquad u_B = \frac{B^2}{2\mu_0} \qquad B = \frac{\mu_0 I}{2\pi r}$$

$$\tau = \frac{L}{R} \qquad \tau = RC$$

$$X_L = \omega L \qquad X_C = \frac{1}{\omega C}$$

$$Z^2 = R^2 + (X_L - X_C)^2 \qquad \tan\phi = \frac{X_L - X_C}{R}$$

Tear off this sheet and use it for the graph required in Q1. Use the grid on the reverse of this page if you need a second sheet.

Family name: ____________________

Other names: ____________________

Student ID: ____________________

Family name: ____________________

Other names: ____________________

Student ID: ____________________

END OF EXAMINATION PAPER

Erratum Sheet

Foundations of Physics, 68101

Friday 18th June, 2004 (2:00 pm – 5:10 pm)

Please note the following two corrections:

Question 6 (a) add "Take $I_0 = 10^{-12}\,\mathrm{W/m^2}$. " to the end of the first line, so it now reads:

At a distance of 3.8 metres from a siren, the sound intensity is $3.6\,\mathrm{W/m^2}$. Take $I_0 = 10^{-12}\,\mathrm{W/m^2}$.

Question 6 (d) Change the marks for this part from [4] to [5].