UTS

University of Technology, Sydney

Cover Page - Type A:

AUTUMN SEMESTER EXAMINATION 1998

FACULTY OF SCIENCE

PHYSICS 1C (F/T, P/T)

68101 and 68081

FRIDAY, 19 JUNE, 1998

START 2:00 PM - FINISH 5:10 PM

TIME ALLOWED: 3 HOURS + 10 MINUTES

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

ANSWER QUESTION 1 AND ANY 5 OTHER QUESTIONS

CALCULATORS MAY BE USED.

ANSWER **EACH** QUESTION IN A **SEPARATE** BOOKLET.

CLEARLY MARK THE QUESTION NUMBER ON THE FRONT OF EACH BOOKLET.

PHYSICS DATA SHEET

$g = 9.80\ ms^{-2}$

$\sigma = 5.670 \times 10^{-8}\ Wm^{-2}\ K^{-4}$

$R = 8.314\ J\ mole^{-1}\ K^{-1}$

$N_o = 6.022 \times 10^{23}$ molecules $mole^{-1}$

$k = 1.381 \times 10^{-23}\ JK^{-1}$ $molecule^{-1}$

$c = 2.998 \times 10^{8}\ ms^{-1}$

$h = 6.626 \times 10^{-34}\ Js$

$\varepsilon_o = 8.854 \times 10^{-12}\ Fm^{-1}$

$\mu_o = 4\pi \times 10^{-7}\ Hm^{-1}$

$e = 1.602 \times 10^{-19}\ C$

$m_e = 9.110 \times 10^{-31}\ kg = 0.00055\ u$

$m_p = 1.673 \times 10^{-27}\ kg = 1.00728\ u$

$m_n = 1.675 \times 10^{-27}\ kg = 1.00866\ u$

$G = 6.673 \times 10^{-11}\ m^2N\ kg^{-2}$

$1u = 1.661 \times 10^{-27}\ kg$

Rydberg's Constant $= 1.097 \times 10^{7}\ m^{-1}$

Temperature of Ice Point $= 273.15\ K$

1 atmosphere $= 1.013 \times 10^{5}\ Pa$

Mass of earth $= 5.974 \times 10^{24}\ kg$

Radius of earth $= 6.37 \times 10^{6}\ m$

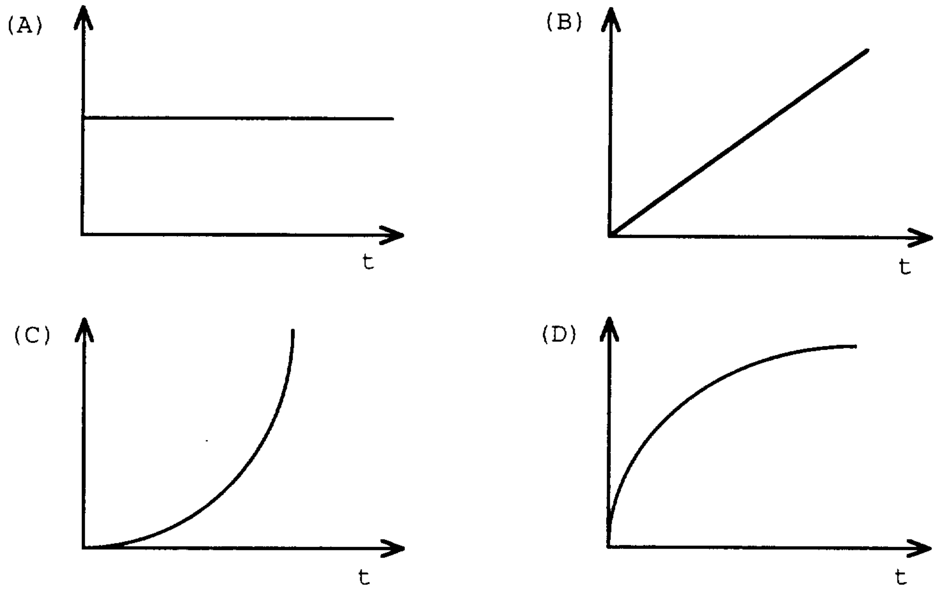
OVER/2

SECTION A
(THIS QUESTION IS COMPULSORY.)

QUESTION 1.

a. Put the answers to the multiple choice question in your examination booklet. Show working where appropriate.

i. An object is dropping under gravity .
Which of the following graphs represents the variation of **velocity** with time?



ii. The brakes of a car bring it to rest from 30 m/s in 5 seconds. The distance travelled is:

A. 150 m B. 75 m
C. 225 m D. 6 m

iii. A boy throws a steel ball straight up into the air. **Disregarding any effects of air resistance**, the force(s) acting on the ball while it is in the air is (are)

A. a constant downward force of gravity and a steadily decreasing upward force

B. a steadily decreasing upward force until it reaches its highest point, after that there is a steadily increasing downward force.

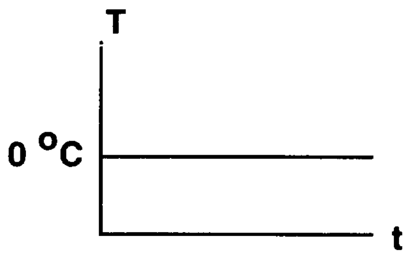
C. a constant downward force of gravity along with an upward force that steadily decreases until the highest point, after that there is only the constant force of gravity

D. a constant downward force of gravity

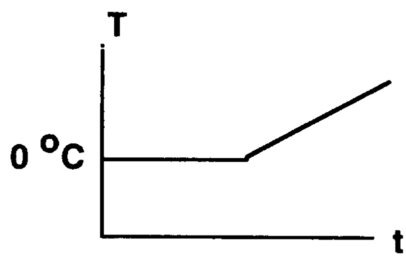
QUESTION 1 (contd.)

iv. A cup contains a mixture of ice and water. Heat is transferred to the mixture. Which of the following graphs of temperature (T) against time (t) would be obtained if before the end of the time interval all the ice has melted.

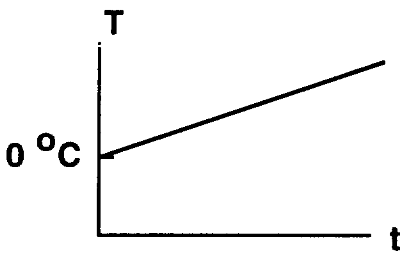
A.



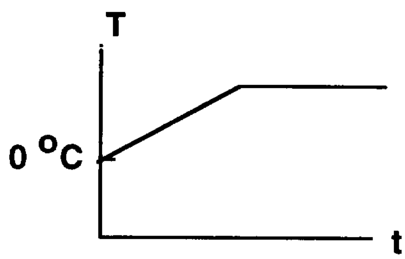
B.



C



D.



E. None of the above

v. What is meant by the elastic limit?

A. the point beyond which the stress is no longer proportional to the strain

B. the point beyond which the object will not return to its original size when the stress is removed

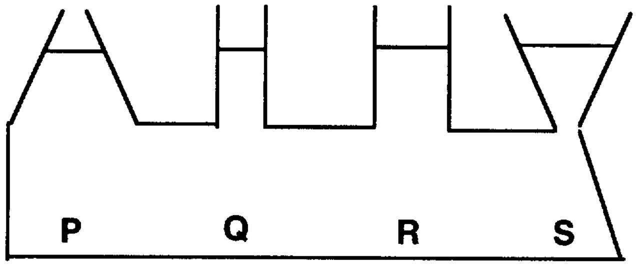
C. the point at which the stress is maximum for the material

D. the point at which the material fractures

E. none of the above

QUESTION 1 (contd.)

vi. Consider the pressure at the points at the bottom of the vessels as shown in the diagram.



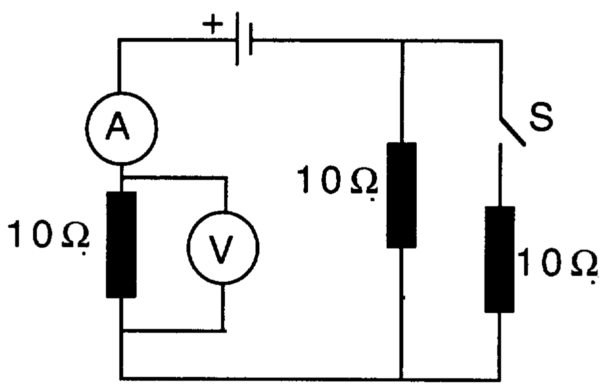
Which is the relative pressures at P, Q, R or S?

A. All pressures are the same.
B. The pressure at P is greater than all the other pressures.
C. The pressure at Q is greater than all the other pressures.
D. The pressure at R is greater than all the other pressures.
E. The pressure at S is greater than all the other pressures.
F. None of the above statements is correct.

vii. For the wave y = 0.1 sin (3x + 10t), what is the wavelength?

A. 6π B. 3π C. $2\pi/3$ D. $\pi/3$

viii. The circuit below consists of an ammeter (A), a voltmeter (V), three 10 Ω resistors and a switch (S).



If the switch S is closed , the readings of

A. A will fall and V will rise
B. A will rise and V will fall
C. A will fall and V will fall
D. A will rise and V will rise.

QUESTION 1 (contd.) Marks

b. i. In an experiment to compare the effectivness of rocket fuels, rockets were fired along a horizontal frictionless track and their velocity measured as a function of time. Results for a particular rocket were:-

Time (seconds)	Velocity (metres/second)
1.00 ± 0.01	16 ± 1
2.00 ± 0.01	30 ± 1
3.00 ± 0.01	46 ± 2
4.00 ± 0.01	61 ± 2

From these figures determine graphically (using the graph paper supplied) the acceleration of the rocket (assumed constant).

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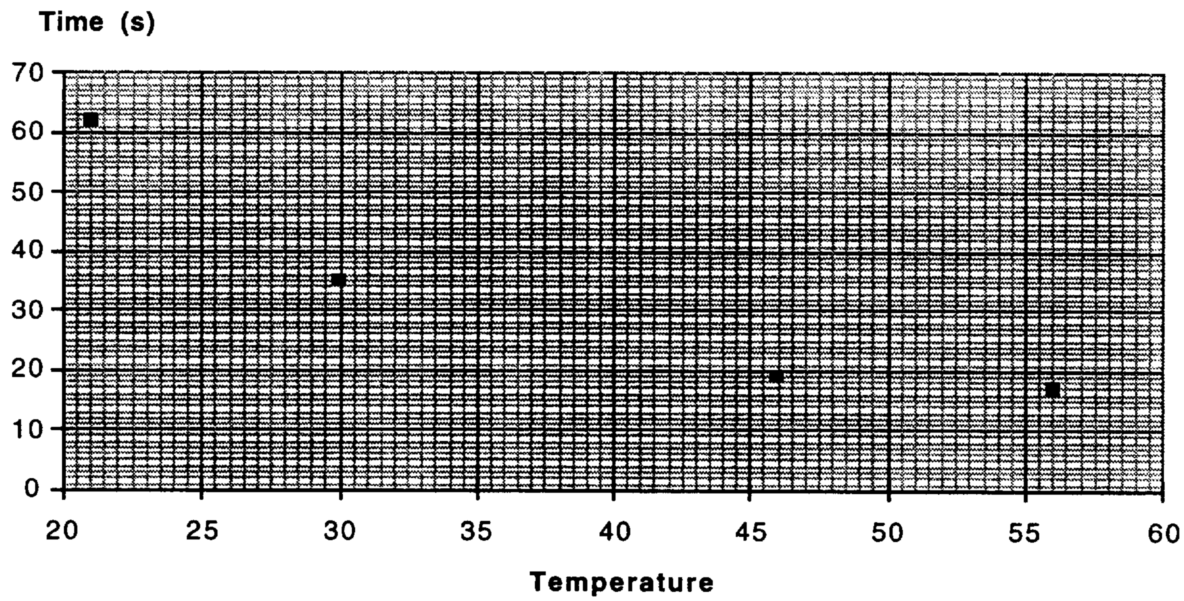
ii. An experiment is performed in which the time for a small metal sphere to fall a fixed distance through a liquid is recorded as the temperature of the liquid increases. The data gathered are shown in the table below and are plotted on the graph. List 4 mistakes.

Temperature (°C)	Time (s)
21	62
30	35
42	22
46	19
52	18

Temperature versus time for a ball falling through a liquid



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QUESTION 1 (contd.) Marks

iii. A student is given a 5 m tape measure and handheld stopwatch. The student is asked to use this equipment to measure the time it takes for a coin to fall through a distance of 4 m. The student repeats the measurement ten times and obtains values between 0.6 s and 1.2 s.

State four possible causes for the variability in the measured values. Which cause do you think is the most important and give your reason(s) for the choice. 3

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SECTION B
(DO ANY <u>FIVE</u> QUESTIONS IN THIS SECTION.)

QUESTION 2. **Marks**

a. i. Explain, with the aid of an example, what is meant when an equation is said to be *"dimensionally consistent"*.

ii. The difference in pressure, Δp, between the air inside and outside of a soap bubble is dependent upon the surface tension of the soap, γ, and the radius of the bubble, R.
Use dimensional analysis to find a dimensionally consistent equation relating Δp to γ and R.

Note: the dimensions of pressure are $[ML^{-1}T^{-2}]$ and the dimensions of surface tension are $[MT^{-2}]$

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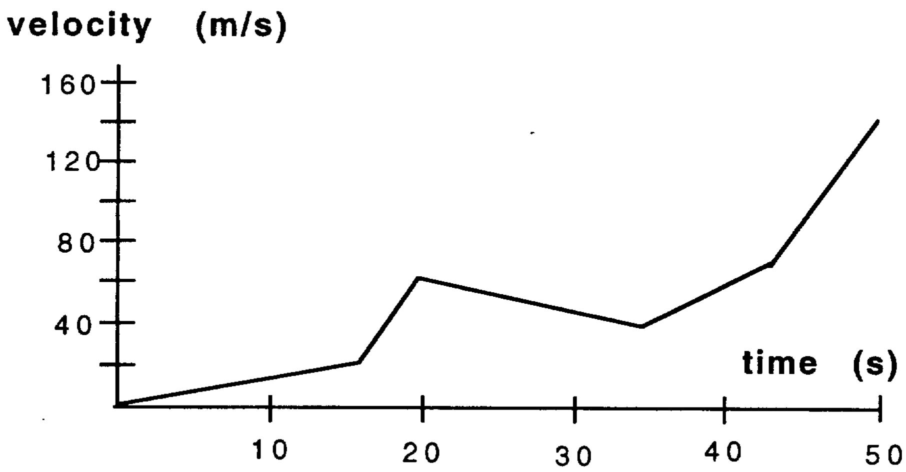
b. Consider the following velocity - time graph



Using the graph above calculate:

i. the <u>approximate</u> acceleration of the body at time = 40 s

ii. the <u>approximate</u> value for the distance travelled by the body between time = 0 s and time = 20 s

iii. the <u>approximate</u> average acceleration of the body between time = 20 s and time = 50 s.

5

QUESTION 2 (contd.) Marks

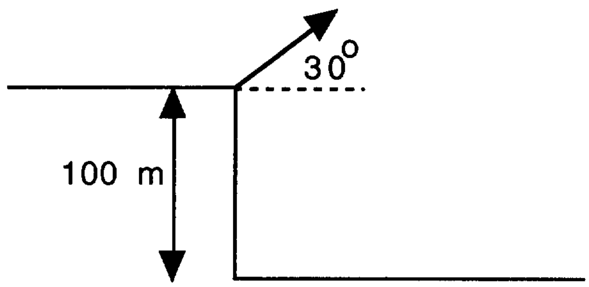
c. Consider the following 2 vectors, A and B, where

$$\underline{A} = -3\underline{i} + 6\underline{j} \quad \text{and}$$
$$\underline{B} = 6\underline{i} + 8\underline{j}$$

Calculate the magnitude and direction of $\underline{A} - \underline{B}$

3

d. A ball is thrown from the roof of a building at a velocity of 20 m/s and at an angle of 30° above the horizontal as shown in the diagram.



If the ball begins its motion at a height of 100 m above the ground,

i. how long will it take to reach the ground?

ii. what will be its horizontal displacement in this time ?

iii. what will be its velocity just before it hits the ground?

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QUESTION 3. **Marks**

a. If you push on a heavy box which is at rest, it requires some force to start its motion. However, once the box is sliding, it requires a smaller force to maintain its motion. Why is this so?

3

b. A skier starts from rest at the top of a frictionless incline of height 20 m and skis, without pushing herself, down the incline. At the bottom of the incline, the skier encounters a horizontal surface where the coefficient of kinetic friction between the skis and the snow of 0.21. How far does the skier travel on the horizontal surface before coming to rest?

6

c. Water, of density 1000 kg m^{-3}, flows over a waterfall at a rate of 1.2×10^6 kg/s and falls 50 m. What is the maximum number of 60 W bulbs that can be lit with the power generated by the waterfall?

5

d. A proton collides in a perfectly elastic fashion with another proton that is initially at rest. The incoming proton has an initial speed of 3.5×10^5 m/s and makes a glancing collision with the second proton. After the collision, one proton moves off at an angle of 37° to the original direction of motion. The second deflects at an angle of 53° to the original direction (i.e. at right angles to the first proton).

i. Determine the final speeds of the two protons

ii. Show that the collision is perfectly elastic.

6

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QUESTION 4. **Marks**

a. Light of wavelength 570.0 nm passes through a container of acetone, which has a refractive index of 1.364. What is

i. the speed of light in acetone,

ii. frequency of the light in acetone,

iii. wavelength of the light in acetone,

iv. critical angle for light passing from acetone to air?

The refractive index of air is 1.000.

5

b. A cylindrical rod of rubber fixed at one end whose Young's modulus is 2.10×10^7 N.m^{-1} is extended from 3.00 m to 3.07 m by attaching a weight to one end of it. The radius of the rod is 13.00 mm.

i. What was the mass of the weight attached?

ii. What is the strain under these conditions?

5

c. A gas (molecular weight = 29), in a cylinder which will fracture at a pressure of 7.3×10^5 Pa, is exposed to heat from a bush fire. The gas is initially at a pressure of 4.3×10^5 Pa and a temperature of 34 °C. The volume of the container (considered constant) is 8.5 litres.

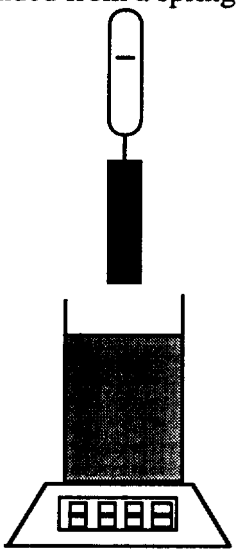
i. How many molecules are initially in the cylinder?

ii. At what temperature will the cylinder fracture?

5

QUSTION 4 (contd.) Marks

d. A beaker of mass 0.055 kg contains 0.120 kg of water (density 1000 kg m^{-3}) and rests on an electronic balance. A 0.15 kg block of aluminium (density 2700 kg m^{-3}) is suspended from a spring balance in air (see diagram).



Determine

i. the volume of the block.

ii. the readings on the electronic balance (in kg) and the spring balance (in N).

If the block is completely immersed in the water, determine,

iii. the new readings on the two balances.

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QUESTION 5. **Marks**

a. An open 250 ml aluminium container is full of glycerine (a liquid with a boiling point of 290 °C) at 20 °C.

The coefficient of linear expansion for aluminium is $2.55 \times 10^{-5}\ K^{-1}$, while the coefficient of volume expansion for glycerine is $5.3 \times 10^{-4}\ K^{-1}$.

i. Explain why the glycerine overflows when the container and contents are heated to 110 °C.

ii. Determine what <u>volume</u> of glycerine spills from the container.

iii. If the density of glycerine at 20 °C is $1.26\ g/cm^3$, what <u>mass</u> of glycerine spills?

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b. Perspiration is the body's natural means of temperature regulation.

i. Explain why perspiration is an effective cooling mechanism.

ii. How much perspiration must evaporate from a 5.0 kg baby to reduce its temperature by 2.5 °C? The heat of vaporisation for water at body temperature is 2.42 MJ/kg, while the specific heat capacity of the human body is 3.47 kJ/kg °C.

6

c. The thermal conductivity of red bricks is $0.60\ Wm^{-1}K^{-1}$, while for a certain timber it is $0.10\ Wm^{-1}K^{-1}$.

i. Which material has better insulating properties? Explain.

ii. What thickness of this wood is needed to give the same insulating ability as an 8.4 cm thick red brick?

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QUESTION 6.

Marks

a. i. On the same diagram sketch 2 cycles of 2 similar sine waves (A and B) with B having a phase 90^{o} ahead of A (indicate clearly which is A and B) .

ii. On the same diagram as part i., and clearly indicated, plot the resulting superposition of waves A and B.

3

b. A 3.00 x 10^{6} kg land mass trembles in a simple harmonic motion (SHM) of amplitude 0.50 m and of period 1.25 s. Calculate:

i. the angular frequency of the SHM

ii. the force constant, k, for the SHM

iii. the maximum velocity of the up and down motion of the land mass

iv. the maximum kinetic energy of the land mass,

v. the restoring force when the displacement is 0.20 m,

vi. the potential energy when the displacement is 0.20 m.

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c. The equation of motion of a travelling wave is $y=0.8 \sin[(x/2)-3.1t]$ where x and y are in metres and t is in seconds. Determine

i. the frequency,

ii. the wave length,

iii. the speed of the wave,

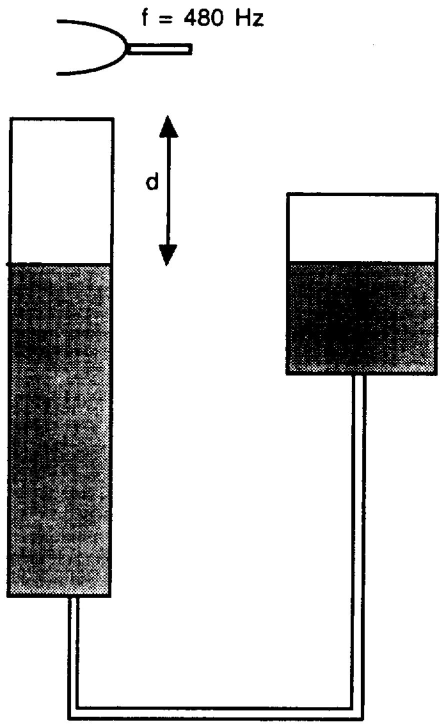
iv. the displacement of a particle when the phase of the wave is $\pi/6$.

6

QUESTION 6 (contd.)

Marks

d. A resonance tube is used to determine the speed of sound using a 480 Hz tuning fork, as shown in the diagram. The water level is gradually lowered from d = 0 mm. The first resonance is found when d = 173 mm and the second when d = 527 mm. Using both pieces of data, determine the speed of sound.



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QUESTION 7. **Marks**

a. An electron is moved from the negative terminal to the positive terminal of a 12 volt battery. How much work is done by the electron in this process?

3

b. A light bulb is made to glow by placing a 3.00 V battery across its terminals. An ideal voltmeter is used to measure the potential difference across the bulb, and an ideal ammeter is used to measure the current flowing through the bulb.

i. Draw a circuit diagram of this arrangement.

ii. If the voltmeter reads 2.80 V and the ammeter 0.345 A, what is the internal resistance of the battery?

iii. If the filament making up the light bulb has a resistivity of 5.51×10^{-8} Ω·m and a cross sectional area of 1.00×10^{-8} m^2 what is the length of the filament?

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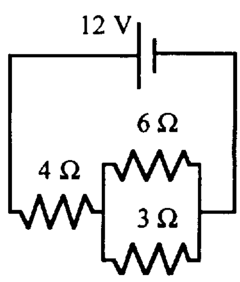
c. Shown below is an electrical circuit;



i. Draw the equivalent circuit showing the value of the equivalent resistance.

ii. What is the power dissipated in the 3 Ω resistor?

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QUESTION 7 (contd.)

Marks

d. The tungsten filament of an electric heater has a resistance of 5.7 Ω at 20 °C. When a potential difference of 240 V is put across the filament its temperature reaches 1300 °C and its resistance increases to 38.4 Ω.

i. What is the temperature coefficient of resistivity of tungsten?

ii. What is the surface area of the filament?

Data: emissivity of tungsten = 0.3

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Mechanics Equation Sheet

$v = u + at$ | $v^2 = u^2 + 2as$ | $s = ut + \frac{1}{2}at^2$

$s = R\theta$ | $v = R\omega$ | $a = R\alpha$

$a = \frac{v^2}{R}$ | $\underset{\sim}{\Gamma} = \underset{\sim}{r} \times \underset{\sim}{F}$ | $\underset{\sim}{\Gamma} = I\underset{\sim}{\alpha}$

$I = I_{cm} + Mh^2$ | $I = Mk^2$ | $x_{cm} = \frac{\int x\,dm}{M}$

Thin Rod	Hoop	Solid Cylinder/Disk	Sphere	Hollow Cylinder
$I = \frac{Ml^2}{12}$	$I = MR^2$	$I = \frac{1}{2}MR^2$	$I = \frac{2}{5}MR^2$	$I = \frac{1}{2}M(a^2 + b^2)$

$\omega = \omega_0 + \alpha t$ | $\omega^2 = \omega_0^2 + 2\alpha\theta$ | $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$P = \underset{\sim}{F} \cdot \underset{\sim}{v}$ | $P = \Gamma\omega$ | $W = \Gamma\theta$

$\underset{\sim}{L} = m\underset{\sim}{r} \times \underset{\sim}{v}$ | $\underset{\sim}{J} = \underset{\sim}{F}\Delta t$ | $\Delta\underset{\sim}{L} = \int \underset{\sim}{\Gamma}dt$

$F = \frac{GMm}{r^2}$ | $U = -\frac{GMm}{r}$

Dynamics Equation Sheet

$a_n = \frac{v^2}{\rho}$ | $a_t = \frac{dv}{dt}$

$a_n = \rho\omega^2$ | $a_t = \rho\alpha$

$W = \Delta K + \Delta U_g + \Delta U_e$ | $U_g = mgy$ | $U_e = \frac{1}{2}kx^2$

Centroidal radius of gyration of rectangle a x b: $k = \sqrt{\frac{(a^2 + b^2)}{12}}$

$K = \frac{1}{2}I_{cm}\omega^2 + \frac{1}{2}Mv_{cm}^2$ | $L_{cm} = I_{cm}\omega$ | $\sum \Gamma_{cm} = I_{cm}\alpha$

Rotation about fixed axis:

$K = \frac{1}{2}I_0\omega^2$ | $L_0 = I_0\omega$ | $\sum \Gamma_0 = I_0\alpha$

Rolling without slipping: $\sum \Gamma_C = I_C\alpha$

Thermal Equation Sheet

$\Delta l = l_0 \, \alpha \, \Delta T$

$\Delta V = V_0 \, \beta \, \Delta T$

$R = R_o(1 + A.T + BT^2)$

$\Delta Q = mc\Delta T$

$\Delta Q = nC\Delta T$

$\Delta Q = mL$

$\frac{dQ}{dt} = -kA\frac{dT}{dx}$

$\frac{dQ}{dt} = -e\sigma A\left(T^4 - T_0^4\right)$

$\frac{dQ}{dt} = \frac{\Delta T}{R}$

$PV = nRT$

$PV = NkT$

$PV^\gamma = \text{constant}$

$PV = \frac{Nm\overline{v^2}}{3}$

$\frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$

$C_p - C_v = R$

$C_v = \frac{3}{2}R$ (mono-), $\frac{5}{2}R$ (di-), $\frac{6}{2}R$(poly-)

$Q = W + \Delta U$

$\Delta U = nC_v\Delta T$

$W = P(V_f - V_i)$

$W = \frac{P_iV_i - P_fV_f}{\gamma - 1}$

$W = nRT \ln\left(\frac{V_f}{V_i}\right)$

$\Delta S = \int \frac{dQ}{T}$

$\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$

$e = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1}$

$\text{C.O.P.} = \frac{Q}{W} = \frac{T_2}{T_1 - T_2}$

Properties of Matter/Fluids Equation Sheet

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

$P = P_0 + \rho g h$ $P + \frac{1}{2}\rho v^2 + \rho g y = \text{constant}$

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

$Q = Av = \text{constant}$ $Q = \frac{\pi R^4 \Delta P}{8\eta l}$ $v_1^2 = \frac{2(P_1 - P_2)}{\left[\rho\left\{\frac{A_1}{A_2}\right\}^2 - 1\right]}$

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

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

Waves/Optics Equation Sheet

$F = -kx$

$T = 2\pi\sqrt{\frac{l}{g}}$

$\omega^2 = \frac{k}{m}$

$U = \frac{1}{2}kx^2$

$x = A \sin(\omega t + \alpha)$

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

$y = 2A \sin kx \cos \omega t$

$c = f\lambda$

$c = \sqrt{\frac{F}{\mu}}$

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

$n_1 \sin i = n_2 \sin r$

$n_1 c_1 = n_2 c_2$

$d_a = \frac{d}{n}$

$P = 2\pi^2 A^2 f^2 \mu c$

$I = 2\pi^2 A^2 f^2 \rho c$

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

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

$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$

$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

$m = -\frac{i}{o}$

$d \sin\theta = m\lambda$

$a \sin\theta = m\lambda$

$a \sin\theta = 1.22\lambda$

$m_l = \frac{250}{f} + 1$

$\alpha = \frac{\pi a \sin\theta}{\lambda}$

$\beta = \frac{\pi d \sin\theta}{\lambda}$

$I = \frac{I_{max} \sin^2\alpha \cos^2\beta}{\alpha^2}$

$I = I_0 \cos^2\theta$

$m_\theta = \frac{f_o}{f_e}$

$R = \frac{\lambda}{\Delta\lambda} = mN$

$D = \frac{d\theta}{d\lambda}$

Electricity A Equation Sheet

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

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

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

Electricity B Equation Sheet

$W = VIt$ $R = \rho\frac{l}{A}$

$\oint \underset{\sim}{E}.d\underset{\sim}{A} = \frac{q}{\varepsilon_0}$ $\underset{\sim}{F} = q\underset{\sim}{v} \times \underset{\sim}{B}$ $\underset{\sim}{F} = i\underset{\sim}{l} \times \underset{\sim}{B}$

$\underset{\sim}{M} = i\underset{\sim}{A}$ $\underset{\sim}{\Gamma} = \underset{\sim}{M} \times \underset{\sim}{B}$

$\oint \underset{\sim}{B}.d\underset{\sim}{l} = \mu_0 I$ $dB = \frac{\mu_0\, i\, dl \sin\theta}{4\pi r^2}$ $\phi_B = \int \underset{\sim}{B}.d\underset{\sim}{A}$

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

$U_B = \frac{1}{2}Li^2$ $U_B = \frac{B^2}{2\mu_0}$

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

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

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