Cover Type A

UTS

University of Technology, Sydney

THIS PAPER MAY BE REMOVED FROM THE EXAM CENTRE.

AUTUMN SEMESTER EXAMINATION 2000

FACULTY OF SCIENCE

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

68101

FRIDAY, 16 JUNE, 2000

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.

FIRST YEAR 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 $= 6.37 \times 10^{6}\ m$

1 Curie $= 3.70 \times 10^{10}$ becquerel

OVER/2

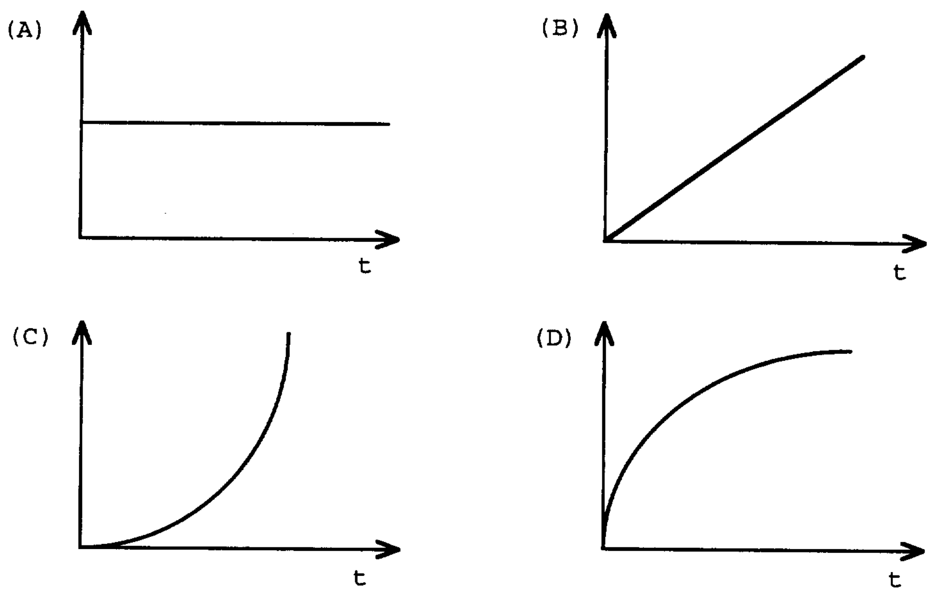
SECTION A

(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. There are 2 spheres made of the same material; one has twice the radius of the other. If they are both at the same temperature, and the smallest one loses heat, by radiation, at a rate of 20 J s^{-1}, at what rate does the larger one loose its heat energy by radiation?

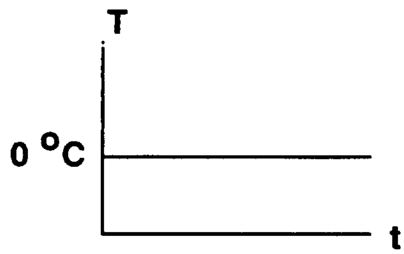
A. 5 J s^{-1} B. 10 J s^{-1} C. 20 J s^{-1}

D. 40 J s^{-1} E. 80 J s^{-1} F. none of A - E

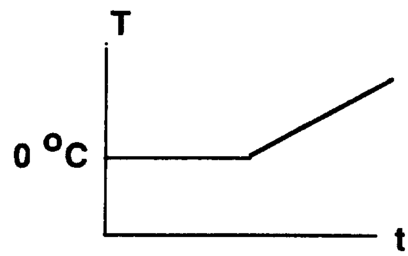
QUESTION 1 (contd.)

iii. 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 part of the way through the time interval all the ice has melted?

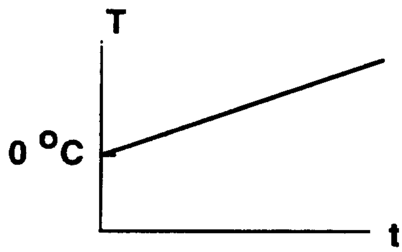
A.



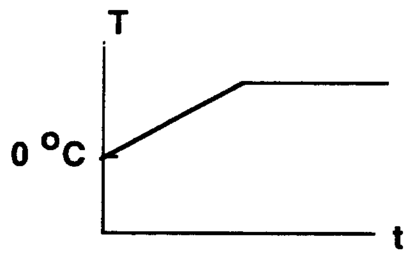
B.



C

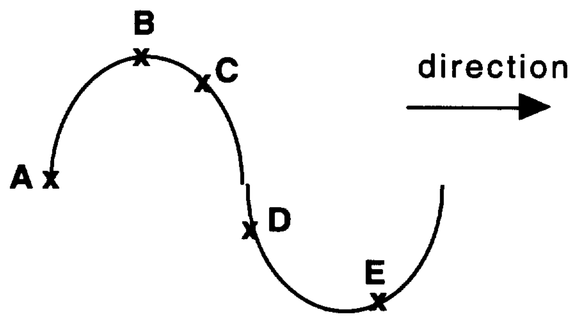


D.



E. None of the above

iv. The diagram shows a travelling wave

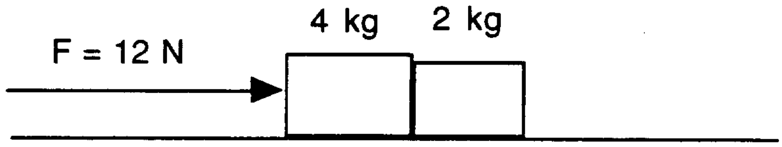


At the instant shown:

A. Particle A is moving the fastest.
B. Particle B is moving the fastest.
C. Particle C is moving the fastest.
D. Particle D is moving the fastest.
E. Particle E is moving the fastest.
F. All particles are moving at the same speed

QUESTION 1 (contd.) Marks

v. A force of 12N is applied to two blocks of mass 4 kg and 2 kg on a frictionless horizontal surface as shown in the diagram.



What is the magnitude of the force exerted by the 4 kg block on the 2 kg block?

A. 2 N B. 4 N C. 6 N D. 12 N

vi. The buoyancy (or upthrust) force on an immersed body has the same magnitude as

A. the weight of the body
B. the weight of the fluid displaced by the body
C. the difference between the weights of the body and the displaced fluid
D.. the average pressure of the fluid times the surface area of the body.

vii. Two identical resistors are connected first in series and then in parallel. Which combination has the larger total resistance?

A. the pair in series
B. the pair in parallel
C. the two combinations have the same resistance
D. none of the above

viii. Two steel balls, one of which weighs twice as much as the other, roll off a horizontal table with the same speed. Compare the horizontal distances from the base of the table where they land.

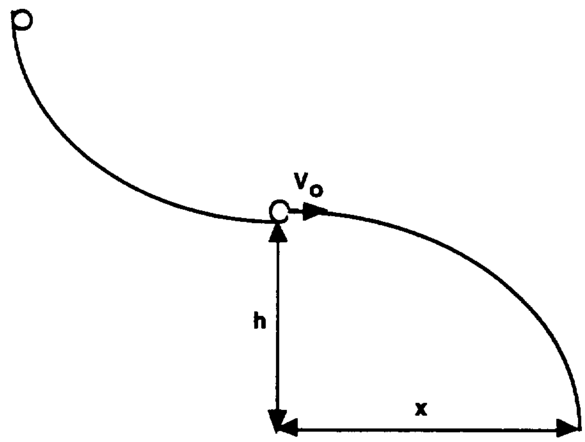
A. both balls hit the floor at approximately the same horizontal distance from the base of the table.
B. the heavier ball hits the floor at about half the distance than does the lighter one
C. the heavier ball hits the floor at about twice the distance than does the lighter one
D. the heavier ball hits the floor at a considerably smaller distance than does the lighter one but not half the distance.
E. the heavier ball hits the floor at a considerably larger distance than does the lighter one but not twice the distance

10

QUESTION 1 (contd.) **Marks**

b. A ball rolls down the curved track shown in the diagram and leaves the track horizontally at a speed, v_o, of 1.8 ms^{-1}.

The height 'h' is varied and the distance 'x' is measured.
According to the theory of projectile motion, $h = 0.5\,g\,x^2 / v_o^2$ where g is the acceleration due to gravity.



The results from the experiment are presented in the following table:

Reading	h (± .001) m	x (±.01) m
1.	0.200	0.37
2.	0.400	0.52
3.	0.600	0.62
4.	0.800	0.72
5.	1.000	0.80

i. In your exam booklet, construct a table including h, x and x^2.

ii. Using one of the x^2 values and the corresponding h value in the Table, calculate the value of g.

iii. The researcher decides to use a graphical method rather than a simple calculation as in part ii. What is the advantage of this?

iii. By drawing an appropriate graph, on the graph paper supplied, calculate the value of g.

10

20

SECTION B.

Attempt any FIVE questions in this Section.

QUESTION 2.

a. The displacement, s, of a particle when moving under uniform acceleration from rest is a function of the elapsed time, t, and the acceleration, a. Showing all working, use dimensional analysis to find a relationship between s, and a and t.

3

b. A student is able to swim at a speed of 1.50 m/s in still water. She wishes to cross a river that has a current of 1.20 m/s. The width of the river is 50 m.

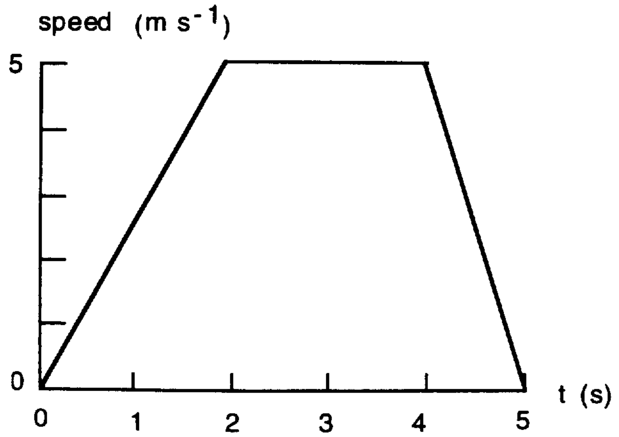
i. If the student wishes to swim to a point on the opposite bank which is directly opposite her starting point, in what direction should she head?

ii. How long would this trip take?

iii. If instead the student aims directly at the opposite bank, how far will she have been swept down the river when she reaches the opposite bank?

6

c. The variation of the tangential speed of a wheel, of radius 2.5 m, with time is shown below;



(part c continues over the page)

QUESTION 2 (contd.) **Marks**

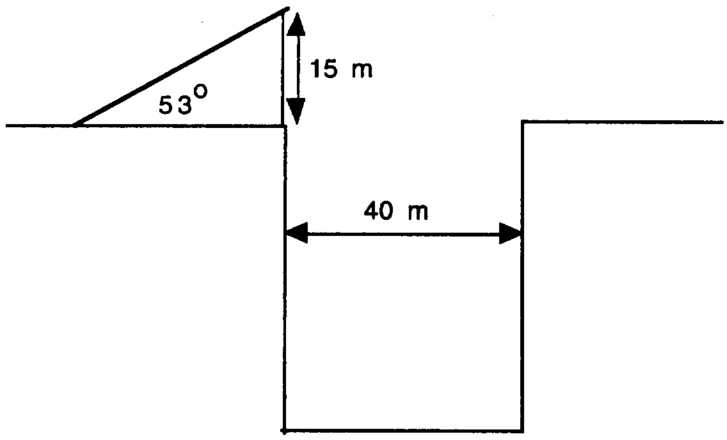
i. Sketch the centripetal acceleration as a function of time from 0 to 5 seconds. State explicitly the functional form of the curves that make up the acceleration versus time curve.

ii. What is the total angle that the wheel rotates through from 2 s to 5 s?

iii. What is the average angular acceleration from 4 s to 5 s?

5

d. A car stunt driver is to attempt a jump across a ravine using a ramp as shown below. The takeoff ramp is inclined at 53°, the ravine is 40 m wide and the top of the ramp is 15 m above the side of the ravine on which the stunt driver is to land.



What should the speed of the car be for the car to reach the edge of the ravine?

6

20

QUESTION 3. **Marks**

a. A train consists of four identical carriages, each of mass 12,500 kg. The train accelerates at a uniform rate of 0.75 m/s^2. Calculate and show by means of a diagram the forces on the front and back of the carriage third from the front.

3

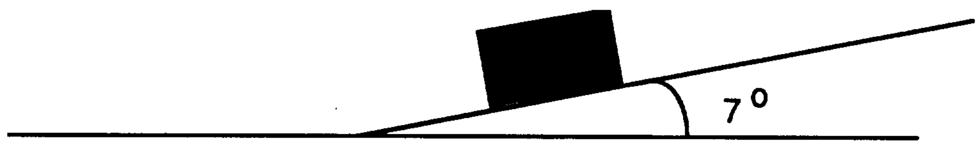
b. An acrobat, Tarzan, (mass = 60 kg) swings on a vine, starting from rest, and picks up his partner, Jane, (mass = 60 kg) who is standing 8.0 m below him on the ground.

(i) After the pick-up, what is the maximum height that they can reach? You may assume that the collision between Tarzan and Jane is perfectly inelastic.

(ii) How much work has been done on Jane?

5

c. In the experiment shown below, which is used to measure the coefficient of kinetic friction, a block slides up an incline until it comes to rest.



In an arrangement that has the incline at an angle of 7° from the horizontal, a block of mass 1.2 kg is found to travel a distance of 0.31 m before it comes to rest following uniform deceleration. Its speed at the start of the incline was measured to be 1.9 m/s.

i. Draw a free-body diagram of the block as it is moving up the incline, showing and naming all forces involved

ii. What is the coefficient of kinetic friction between the block and the incline?

iii. What is the total work done on the block by gravity?

7

QUESTION 3 (contd.) **Marks**

d. Two cars travelling perpendicular with respect to each other collide and stick together. At the point just before the collision, the car travelling in the $+\hat{x}$ direction has a mass of 2000 kg, and a speed of 10 m/s, while the car travelling in the $+\hat{y}$ direction has a mass of 1000 kg and a speed of 15 m/s.

(i) What is the initial speed and direction of the two cars immediately after the collision? Ignore any frictional forces between the cars and the road.

(ii) What is the change in kinetic energy due to the collision?

5

20

QUESTION 4. **Marks**

a. i. Steel ($\alpha = 1.2 \times 10^{-5}\ K^{-1}$) rails, of length 8.3 m, for a railway line are laid at a temperature of 18 °C. If the maximum temperature in the location is 50 °C, what distance must be left between the rails in order that the rails don't touch at 50 °C?

ii. What is the distance between the rails on a cold winter's morning at - 2.0 °C?

5

b. Calculate the total energy radiated per second from the sun if its emissivity is 1.0. (radius of the sun = 6.96×10^{8} m, temperature of the sun = 5800 K, temperature of space = 3K)

3

c. A water heater of dimensions 1.2 m x 0.8 m x 0.4 m is covered by 18 mm of insulation (k = 0.34 in S.I. units) on all sides. Calculate:

i. the total mass of water in the tank (density of water = 1000 kg m^{-3}).

ii. the total surface area of the tank

iii. the rate at which heat flows from the tank, by conduction, if the water temperature is 80 °C and the room temperature is 18 °C.

iv. the amount of heat energy lost from the tank when the temperature of the hot water drops from 80 °C to 78 °C? (specific heat of water = 4200 J kg^{-1} K^{-1})

v. the time taken for the temperature to fall from 80 °C to 78 °C.

8

d. i. At what rate must heat flow into 2.36 kg of ice if it is to melt in 1 hour? (heat of fusion for ice = 3.35×10^{5} J kg^{-1})

ii. If the heat is supplied by solar radiation falling onto a 0.5 m x 0.5 m surface of ice, what is the intensity (energy/second/square metre) of the solar radiation?

4

20

QUESTION 5. **Marks**

a. A steel cable used for an 800 kg lift is 80 m long and has a diameter of 68 mm.
[For steel :- Young's modulus = 1.2×10^{11} N m^{-2}, Elastic limit = 9.6×10^{7} N m^{-2}, Ultimate strength = 5.0×10^{8} N m^{-2}]
Determine:

i. the stress on the cable when the empty lift is stationary

ii. the strain in the cable when the empty lift is stationary

iii. the extension of the cable when the empty lift is stationary

iv. the number of passengers (70 kg) that the stationary lift can hold without the stress exceeding 10 % of the elastic limit.

6

b. i. A barometer reads 0.758 mm Hg (density 13,600 kg m^{-3}). What is the atmospheric pressure in pascals?

ii. What is the pressure 150 mm under the surface of water in a large beaker?
(use the atmospheric pressure from part i. and the density of water = 1000 kg m^{-3})

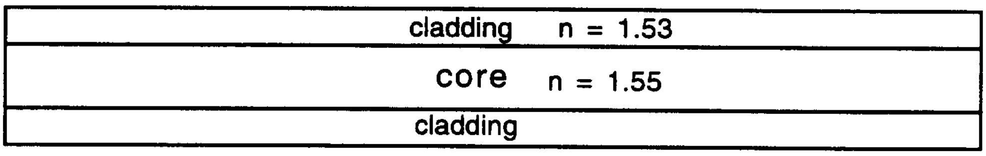
iii. What is the pressure inside a bubble of radius 0.05 mm in the beaker of water (part ii) 150 mm below the water surface?
(surface tension of water = 0.08 N m^{-1})

6

c. A hot air balloon has to lift a basket of mass 120 kg and 7 people of average mass 70 kg. What volume of air is required if the density of cool air is 1.28 kg m^{-3} and the density of the hot air is 0.82 kg m^{-3}?

4

d. A fibre optic cable consists of a central core of refractive index 1.55 and outer cladding of refractive index 1.53 (see diagram).



i. What is the critical angle for light travelling from the core to the cladding?

ii. What is the speed of light in the core?

4

20

QUESTION 6. **Marks**

a. The sound from an explosion bounces back off a wall and 1.7 s after the explosion the echo is heard at the place of the explosion. If the speed of sound in the air is 338 m s^{-1}, how far away is the wall? 2

b. An 0.52 kg object is placed on a frictionless plane and attached by a spring to a fixed end (as shown in the diagram).

A force of 5.1 N is required to displace the object 48 mm to the right. It is then let go. Determine:

i. the force constant of the spring
ii. what the motion of the object is called after being let go.
iii. the period of the motion.
iv. the maximum speed of the object.
v. the equation for the motion in the form displacement, x = ?

7

c. The equation $y = 3.0 \sin (8x - 72t + \pi/6)$ represents the motion of a travelling wave where x and y are in metres.
Determine:

i. the direction in which the wave is travelling
ii. the wavelength of the wave
iii. the frequency of the wave
iv. the amplitude of the wave
v. the speed of the wave
vi. the equation of the wave which when combined with the one above will produce a standing wave.

8

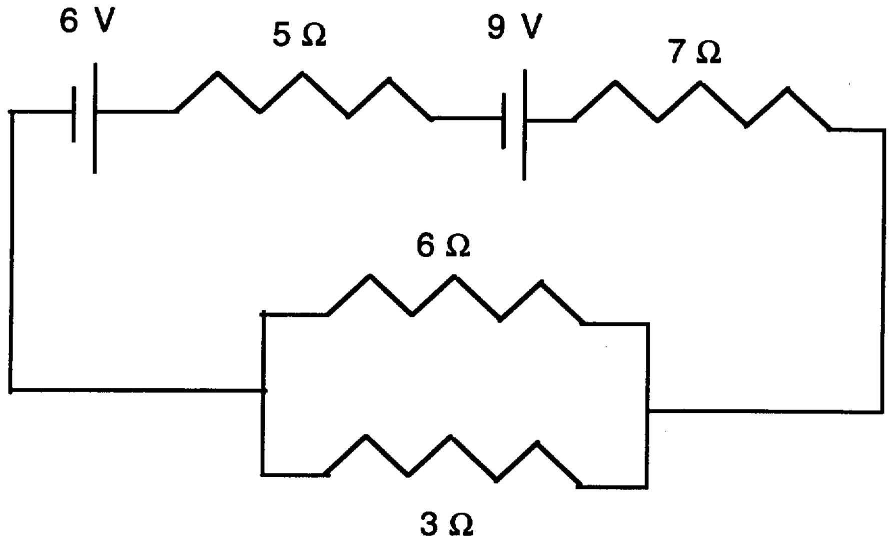
d. A lawn mower gives a sound level reading of 84 decibels. What would be the reading if there were 5 identical lawn mowers next to each other? ($I_0 = 1.0 \times 10^{-12}$ W m^{-2})?

3
20

QUESTION 7. Marks

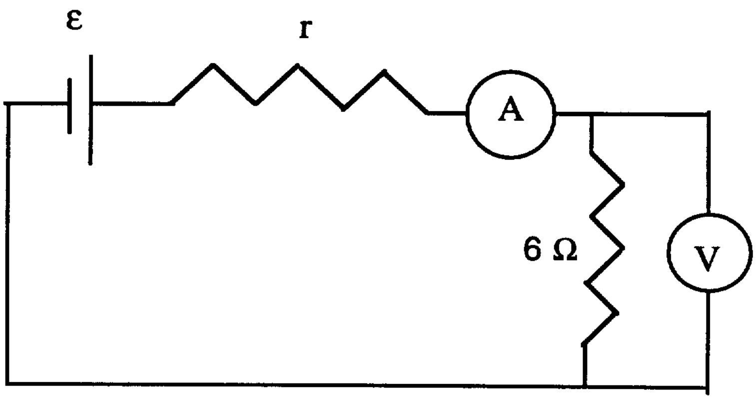
a. i. State Kirchoff's current and voltage rules and their corresponding conservation laws.

ii. What current flows through the 6 Ω resistor in the circuit shown below?



6

b. In the following circuit the readings on the ammeter is 0.928 A, and the reading on the voltmeter is 5.57 V. The resistance of the ammeter is 2.20 Ω and that of the voltmeter can be taken as infinite.



i. Given the emf, e, of the battery is 12 V, find the internal resistance, r, of the battery.

ii. What is the rate of energy dissipation in the 6Ω resistor?

5

QUESTION 7 (contd.) **Marks**

c. Silver has a resistivity of 1.47×10^{-8} Ω·m at 0 °C, and a temperature coefficient of resistivity of 0.0038 $(C°)^{-1}$ over the temperature range of interest in this problem. A certain length of 1.00 mm diameter silver wire has a resistance of 0.0700 Ω at 0 °C. What length of wire would be needed to give the same resistance produced by raising the temperature (of the initial length) to 100 °C?

4

d. A deuteron (the nucleus of a hydrogen atom consisting of a proton and a neutron) has a mass of 3.34×10^{-27} kg and a charge of $+e$. The deuteron travels in a circular path with a radius of 6.96 mm in a magnetic field of 2.50 T.

i. Find the speed of the deuteron.

ii. Through what potential would the deuteron have to be accelerated to acquire the same speed?

5

20

Mechanics Equation Sheet

$\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M = 0$

$F = ma$

$F = \mu N$

$F = -ks$

$W = Fs$

$W = -\frac{1}{2} ks^2$

$PE = mgh$

$P = Fv$

$KE = \frac{1}{2} mv^2$

$p = mv$

$I = Ft$

$\bar{v}_{ac} = \bar{v}_{ab} + \bar{v}_{bc}$

$s = ut + \frac{1}{2} at^2$

$v = u + at$

$v^2 = u^2 + 2as$

$c^2 = a^2 + b^2 - 2ab \cos C$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$

$\theta = \omega_o t + \frac{1}{2} \alpha t^2$

$\omega = \omega_o + \alpha t$

$\omega^2 = \omega_o^2 + 2\alpha\theta$

$s = R\theta$

$v = R\omega$

$a = R\alpha$

$a_n = \frac{v^2}{R} = \omega^2 R$

$T = Fr$

$I_C = Mk^2$

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

$L = I\omega$

$\Delta L = Tt$

$W = T\theta$

$KE = \frac{1}{2} I\omega^2$

$P = T\omega$

Thermal Equation Sheet

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

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

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

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

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

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

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

$W = \frac{P_iV_i - P_fV_f}{\gamma - 1}$ $W = nRT \ln\left(\frac{V_f}{V_i}\right)$

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

Waves/Optics Equation Sheet

$F = -kx$

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

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

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

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

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

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

$c = f\lambda$

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

$n_1 \sin i = n_2 \sin r$

$n_1 c_1 = n_2 c_2$

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

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

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

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

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

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

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

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

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

$d \sin\theta = m\lambda$

$a \sin\theta = m\lambda$

$a \sin\theta = 1.22\lambda$

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

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

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

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

$I = I_0 \cos^2\theta$

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

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

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

Electricity and Magnetism Equation Sheet

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

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

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

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

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

$\underset{\sim}{M} = i\underset{\sim}{A}$ $\underset{\sim}{\Gamma} = \underset{\sim}{M} \times \underset{\sim}{B}$ $\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi a}$

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

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

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

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

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

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

Properties of Matter/Fluids Equation Sheet

$$Y = \frac{F/A}{\Delta l/l_0}$$

$$B = \frac{-\Delta p}{\Delta V/V_0}$$

$$S = \frac{F/A}{d/y}$$

$$\sigma = \frac{-\Delta b/b_0}{\Delta l/l_0}$$

$$P = P_0 + \rho g h$$

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

$$v = \sqrt{2gh}$$

$$\gamma = \frac{F}{l} = \frac{W}{\Delta A}$$

$$h = \frac{2\gamma\cos\theta}{\rho g R}$$

$$\Delta P = \frac{2\gamma}{R} \text{ or } \frac{4\gamma}{R}$$

$$Q = Av = \text{constant}$$

$$Q = \frac{\pi R^4 \Delta P}{8\eta l}$$

$$v_1^2 = \frac{2(P_1 - P_2)}{\left[\rho\left\{\left(\frac{A_1}{A_2}\right)^2 - 1\right\}\right]}$$

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

$$F = 6\pi\eta R v$$

$$N_R = \frac{\rho v D}{\eta}$$

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