UTS

University of Technology, Sydney

Cover Page - Type A:

SPRING SEMESTER EXAMINATION 1997

APPLIED GEOLOGY, APPLIED CHEMISTRY, APPLIED PHYSICS

AND MATERIALS SCIENCE DEGREE

PHYSICS 1 (F/T, P/T)

68101 and 68081

MONDAY, 1 DECEMBER, 1997

START 9.30 AM - FINISH 12.40 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

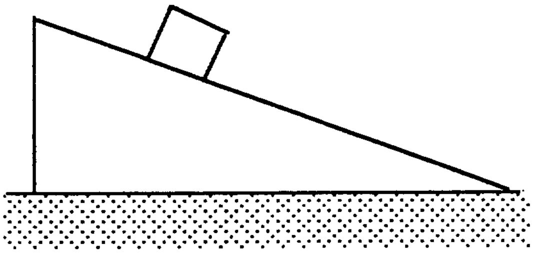
SECTION A

(THIS QUESTION IS COMPULSORY.)

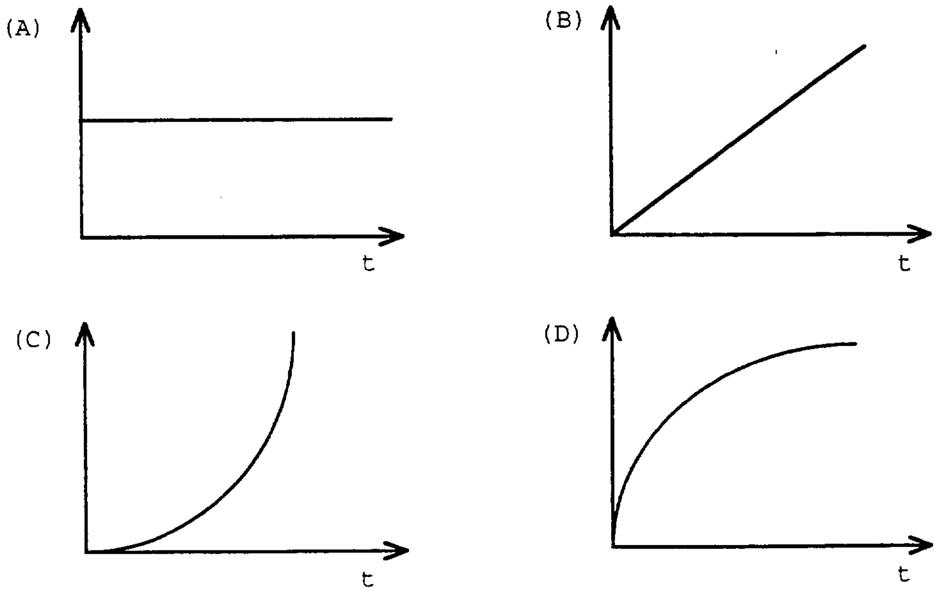
QUESTION 1.

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

i. A block is sliding down a frictionless incline, as shown in the diagram below.



Which of the following graphs represents the variation of **distance** with time?



ii. 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)

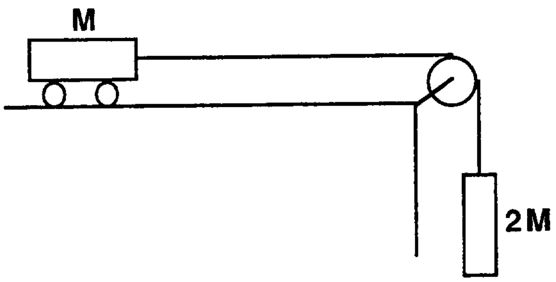
A. a constant downward force of gravity and a steadily decreasing upward force

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

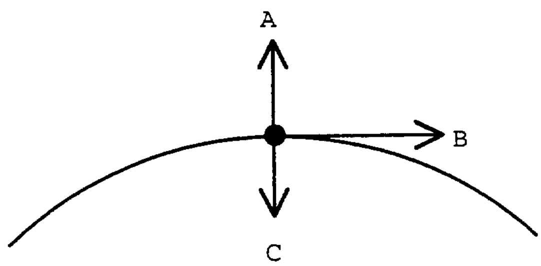
iii. The diagram shows a trolley of mass M on frictionless bearings being accelerated by a falling object of mass 2 M.



The acceleration of the trolley is

A. g/3 B. g/2 C. 2g/3 D. g E. 2g

iv. A body moves in an arc of a circle as shown below with constant speed. Which of the following statements is correct?



A. There is a force acting in the direction A.

B. There is a force acting in the direction B.

C. There is a force acting in the direction C.

D. There is no force acting since the body is moving with constant speed.

v. Cup A contains 100 grams of water. Cup B contains 200 grams of water.

Both are initially at room temperature (25 °C).

The water in Cup A is heated to 75 °C. The water in Cup B is heated to 50 °C.

The water in which cup has more heat been transferred to?

(Ignore the heat transferred to the cup itself)

A. Cup A

B Cup B

C. Heat transfer the same for each cup

D. Not enough information given.

vi. There are 4 identical rods. (All are made of the same metal and have the same shape). The sides of the rods are insulated so that no heat can flow in or out. The temperatures at each end of the rods are as follows:-

A. 0 °C & 50 °C

B. 50 °C & 90 °C

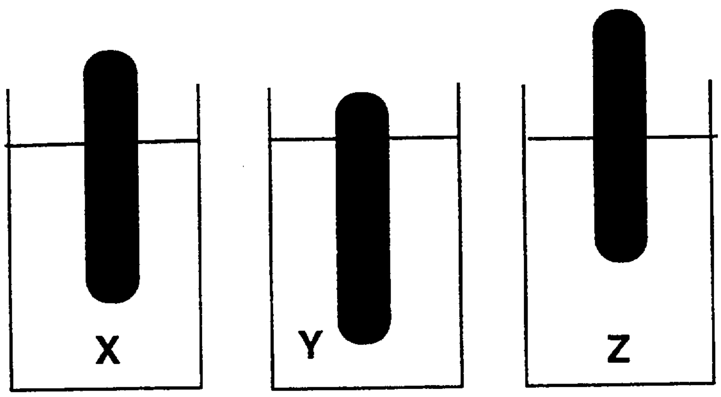
C. -10 °C & 30 °C

D. 30 °C & 60 °C

Along which rod does heat flow at the <u>slowest</u> rate?

Answer E if you think the heat flows at the same rate for each rod.

vii. The depth to which an object sinks in various liquids is shown in the diagram. What can be said about the densities of X, Y and Z?

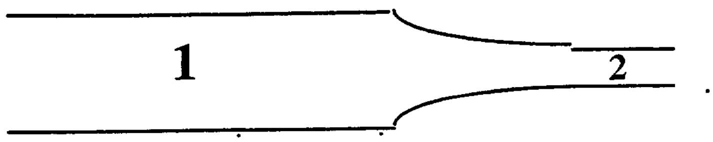


A. $\rho_z < \rho_x < \rho_y$ B. $\rho_z > \rho_x > \rho_y$ C. $\rho_z = \rho_x = \rho_y$

D. $\rho_x < \rho_y < \rho_z$ E. $\rho_x > \rho_y > \rho_z$ F. none of the above

Marks

vii. In the following diagram water flows out of a hose through a nozzle.



If v is the velocity of the fluid, and P is the pressure of the fluid, what is the relationship between the velocities and pressures at 1 and 2?

A. $v_2 > v_1$, $P_2 > P_1$ B. $v_2 > v_1$, $P_2 < P_1$

C. $v_2 < v_1$, $P_2 > P_1$ D. $v_2 < v_1$, $P_2 < P_1$

E. none of the above.

10

b. i. A student decided to determine, g, the acceleration due to gravity, using the formula for the period of a pendulum

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

where L is the length of the string. Discuss briefly how the experiment could be done.

ii. The student records the following values when the mass of the pendulum bob is 0.200 kg

No.	L (m)	T (s)	T^2 (s^2)
1.	0.10	0.634	
2.	0.20	0.900	
3.	0.30	1.11	
4.	0.40	1.26	
5.	0.50	1.43	
6.	0.60	1.55	

Complete the table (in your answer booklet)

iii. To determine a rough value of g, use one value of L and the corresponding value of T.

iv. To obtain a more accurate value, the student used a graphical method to determine the value of g and the accuracy of the value. Explain why a graphical method would be used to give increased accuracy, and how the accuracy could be obtained?

v. Use the graph paper supplied to determine the value of g.

10

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SECTION B

(ATTEMPT ANY **FIVE** QUESTIONS IN THIS SECTION.)

QUESTION 2. **Marks**

a The speed of an ocean wave, c, is thought to depend on its wavelength, λ, and the acceleration due to gravity, g. Use dimensional analysis to suggest a relationship between c, λ and g. 4

b. A block of mass 11 kg is at rest on a horizontal surface when a horizontal force of 35 N is applied to the block. Given that the coefficients of friction between the block and the surface are $\mu_s = 0.35$ and $\mu_k = 0.30$, does the block,

i. remain at rest?

ii. move with constant velocity?

iii. move with constant acceleration?

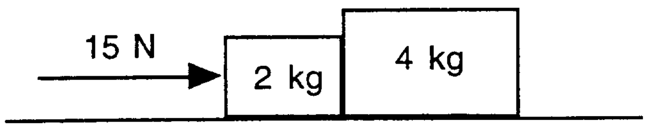
Fully explain your answers. 3

c. A student is swinging a bucket of mass 7.0 kg in a horizontal circle of radius 4.1 m on the end of a rope. If the rope will break at a tension of 700 N, calculate the maximum speed the bucket can have while still in circular motion. 3

d. In the following diagram, determine

i. the acceleration of the masses, and

ii. the reaction forces between the masses.



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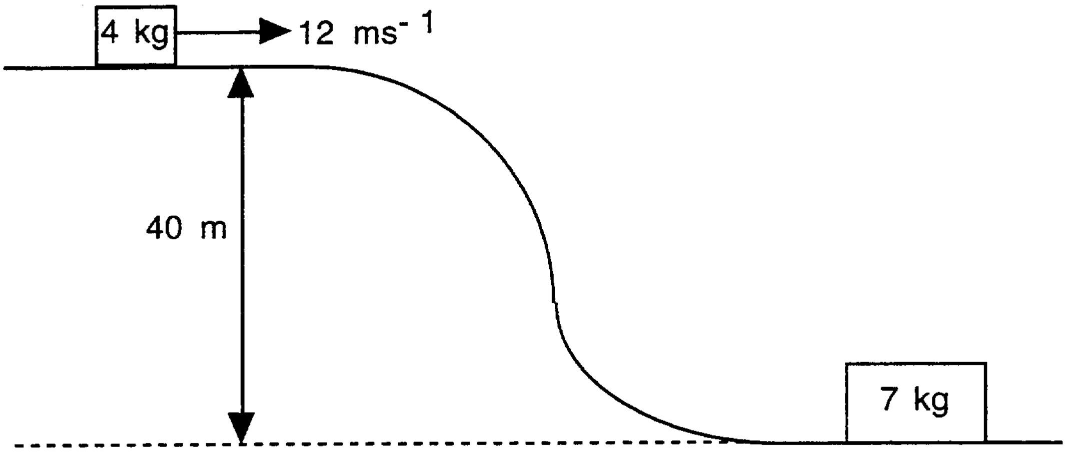
e. i. A body has a mass of 4 kg, and its horizontal velocity at the top of a hill is 12 m/s. If the vertical height of the hill is 40 m, calculate the kinetic energy and velocity of the body when it reaches the bottom of the hill. (Assume no friction is acting.)

ii. At the bottom of the hill, the 4 kg body now collides with and sticks to a 7 kg body originally at rest. What is the final velocity?



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QUESTION 3.

a. 3 forces act on a single object of mass 25 kg - 3.92 Newtons to the east,

4.95 Newtons to the south, and 1.90 Newtons to the west. Find the magnitude and direction of the acceleration.

4

b. An object is thrown from the ground into the air at an angle of 30° to the horizontal.

8 seconds later it lands back on the ground. Determine

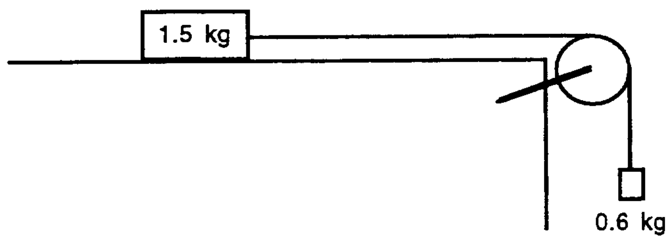
i. the initial velocity

ii. the maximum height reached

ii. the horizontal distance travelled until it reaches the earth

6

c. A small block with mass m = 1.5 kg rests on a horizontal frictionless tabletop. A string joins the mass m to another mass M = 0.60 kg hanging from a smooth pulley at the edge of the table as shown in the diagram.



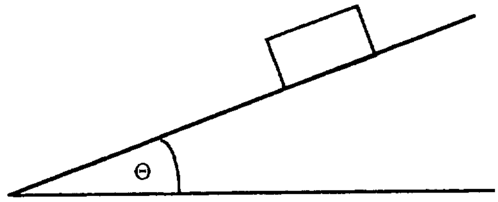
Calculate

i. the acceleration of the mass m,

ii. the tension in the string.

5

d. An object of mass 3 kg, rests on a plane in which the angle of inclination, θ, is increased, as shown in the diagram. It is found that at an angle of 20° object starts to move, and then once moving it accelerates at a rate of 0.4 ms^{-2}.



i. Show all the forces acting on the 3 kg object.

ii. Calculate the coefficient of static friction.

iii. Calculate the coefficient of kinetic friction.

5

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QUESTION 4. Marks

a. A wheel starts from rest under the influence of a constant torque and turns through 30 revolutions in 25 seconds. Determine:-

i. its angular acceleration

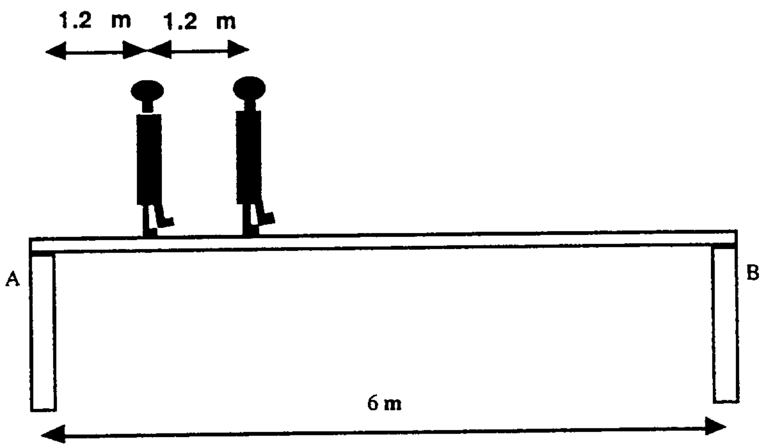
ii. its angular velocity after 25 seconds.

3

b. People are walking across a 6.0 metre long uniform wooden plank supported at each end (A and B). At a particular instant two 75 kg people are on the plank as shown in the diagram. The mass of the plank is 800 kg.

i. show all the forces acting on the plank

ii. calculate the reaction forces at each support.



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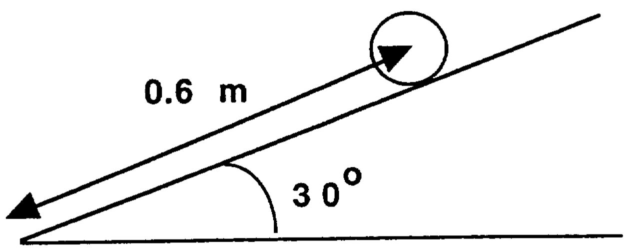
c. A solid cylinder (of radius 7.0 mm and length 8.0 mm) and a solid sphere (of radius 7.0 mm) rolls from rest down a plane inclined at 30° to the horizontal. If both objects have a mass of 15.2 grams, determine

i. the final velocity of each object after it has rolled 0.6 m down the plane (as shown in diagram),

ii. which object will reach the bottom first - explain your answer.



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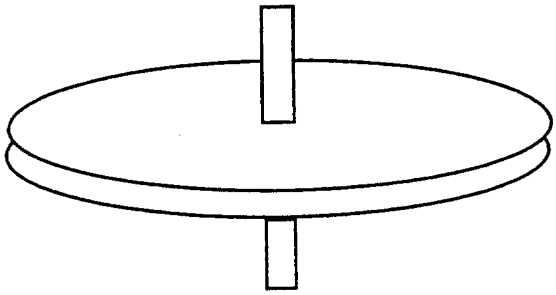
QUESTION 4 (contd.) **Marks**

d. A footballer in training has to run and jump onto a 450 kg rotating table on its rim. He is running tangentially to the table and in the same direction as the table is moving. The table has a radius of 2.0 m, and a radius of gyration of 1.4 m. If the original angular velocity of the table is 12 revolutions per minute, and the mass of the footballer is 105 kg and his velocity is 7.4 ms^{-1}, determine

i. the moment of inertia of the rotating table

ii. the final angular velocity of the table in revolutions per minute.



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QUESTION 5.

a. i. A glass flask with a volume of 200 cm^3 is filled to the brim with mercury at 20°C.

α. Explain why the mercury overflows when the temperature of both mercury and glass are raised to 100°C.

β. Calculate how much mercury spills.

The coefficient of volume expansion of glass is 1.2×10^{-5} K^{-1} and the coefficient of volume expansion for mercury is 18×10^{-5} K^{-1}.

6

ii What final temperature does 0.25 kg of water reach if 0.050 grams of ice at -15°C are added to it?

The heat of fusion of water is 3.34×10^5 J kg^{-1} , the specific heat capacity of water is 4.190×10^3 J kg^{-1} K^{-1}, and the specific heat capacity of the ice is 2.01×10^3 J kg^{-1} K^{-1}.

5

b. i. A uniform copper rod of length 50 cm has one end maintained at 100°C and the other is held at a constant 0°C. The rod has a cross-sectional area of 3.00 cm^2 and the thermal conductivity of copper is 385 Wm^{-1} K^{-1}.

α. Calculate the amount of heat that flows through the rod per second.

β. Calculate the temperature at the point 20 cm from the hot end.

γ. How would the answer for α. change if the area was 4 times as large?

6

ii. An engine operates between a high temperature of 400 °C and a low temperature of 30 °C and its efficiency is 0.40. Is it theoretically possible to build a more efficient engine operating between these two temperatures? Give the reason for your answer.

3

20

QUESTION 6

a. The root mean square speed of molecules in a gas is 300 m/s when the temperature of the gas is 40 °C. What is the root mean square speed when the temperature is increased to 120 °C? 2

b.. 2.0 moles of an ideal monatomic gas is initially at a pressure of 1.0×10^5 Pa and at a temperature of 60 °C. It is then compressed at constant temperature. 2000 J of work is required to compress the gas. Finally it is allowed to expand slowly without any heat entering or leaving the gas until the volume returns to its initial value.

α. Use a pressure versus volume diagram to show the changes undergone by the gas.

β. Calculate the initial volume of the gas.

γ. Does heat enter or leave the gas as it is compressed? Calculate the amount of heat that flows.

δ. Calculate the volume of the gas when it is compressed.

8

c. Draw a stress-strain curve for a ductile metal under tension. Indicate on the graph the ultimate strength and the fracture point. 2

d. A lift of mass 1200 kg is supported by a steel cable 30 mm in diameter and 90 m in length.
Determine

i. the stress in the cable when the lift is empty;
ii. the amount the cable stretches; and,
iii. the maximum number of people (each of mass 70 kg), the stationary lift can hold if 10% of the ultimate strength is not exceeded.

For steel, Young's Modulus = 2.1×10^{11} N m^{-2}
Ultimate Strength = 5.2×10^{8} N m^{-2}

5

QUESTION 6 (CONTD.) Marks

e. i. Explain briefly how a mercury barometer measures the atmospheric pressure.

ii. A mercury barometer reads 758.75 mm Hg. What is atmospheric pressure in pascals? (density of mercury = 13600 kg m^{-3})

4

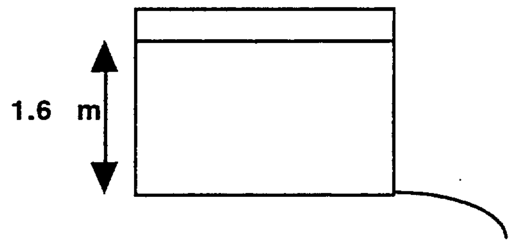
20

QUESTION 7.

a. If the density of ice is 920 kg m^{-3} and the density of salt water is 1025 kg m^{-3} what proportion of an iceberg floats <u>above</u> the water?

3

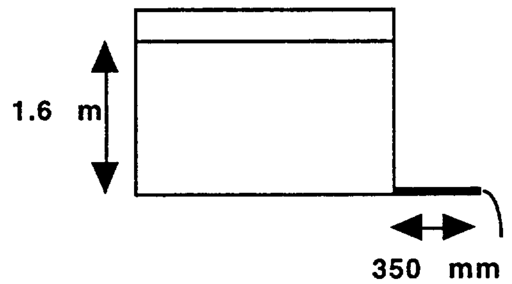
b. A hole, of radius 0.5 mm, develops near the bottom of a cylindrical water tank (3.1 m in diameter). The hole is 1.6 m below the surface of the water. (density of water = 1000 kg m^{-3}) (See diagram)



i. What is the initial speed of the water out of the hole?
ii. What is the initial volume rate of flow out of the tank?
iii. Why does the volume rate of flow decrease as the tank empties?
iv. How long will it take the tank to empty if the average volume rate of flow out of the tank is half that calculated in part ii?

6

c. A tube, of length 350 mm and an internal radius of 0.5 mm, is connected to the hole in part b (see diagram).



i. What is the volume rate of flow through the tube if the viscosity of water is 1.21×10^{-3} Pa.s, and the depth of water is 1.6 m?
ii. Compare with your answer in b ii. Why is it different?

4

QUESTION 7 (contd.)

d. The surface tension of mercury is 0.465 N m^{-1} and its angle of contact with glass is 140^o. A glass capillary tube of radius 3.2 mm is placed in a bowl of mercury.

i. What is the height of the mercury in the tube relative to that in the bowl?

ii. Show the situation in a diagram, clearly indicating the levels of the mercury inside and outside the capillary tube.
(density of mercury = 13600 kg m^{-3})

4

e. Explain by words and diagrams what is meant by laminar and turbulent flow.
Give examples.

3

20

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: $\sum \Gamma_C = I_C\alpha$

OVER/18

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-)

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

$W = \frac{P_iV_i - P_fV_f}{\gamma - 1}$ | $W = nRT \ln\left(\frac{V_f}{V_i}\right)$ | $\Delta S = \int \frac{dQ}{T}$

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

Properties of Matter/Fluids Equation Sheet

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

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

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

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

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

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