University of Technology, Sydney

Cover Page - Type A:

AUTUMN SEMESTER EXAMINATION 1997

APPLIED GEOLOGY, APPLIED CHEMISTRY, APPLIED PHYSICS

AND MATERIALS SCIENCE DEGREE

PHYSICS 1 (F/T, P/T)

68101 and 68081

WEDNESDAY, 25 JUNE, 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

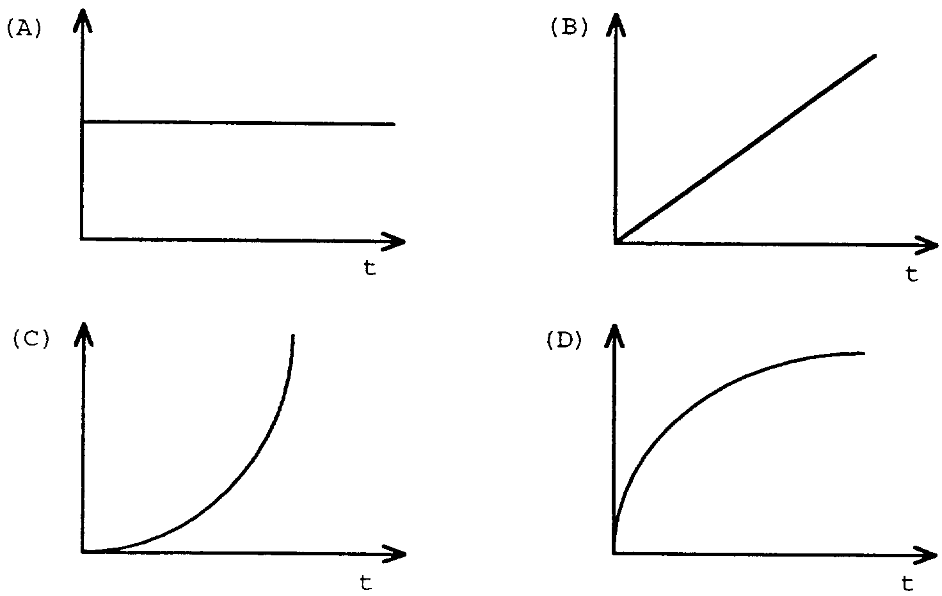
SECTION A

(THIS QUESTION IS COMPULSORY.)

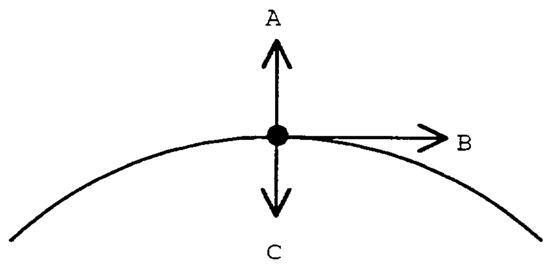
QUESTION 1.

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

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



ii. 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.

QUESTION 1 (contd.) Marks

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)

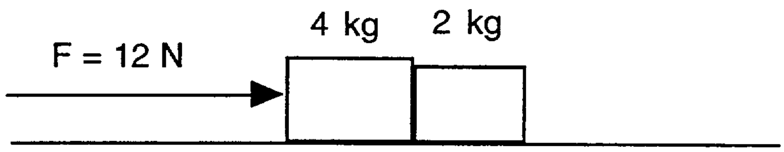
A. a constant downward force of gravity and a steadily decreasing upward force

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 only

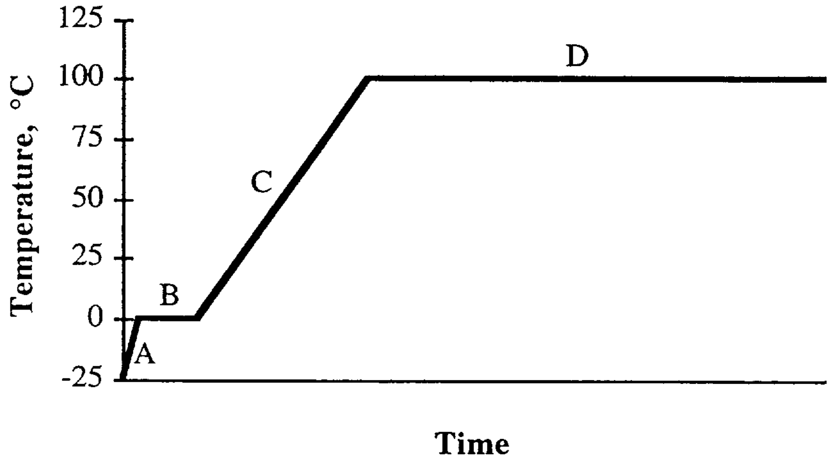
iv. A force of 12N is applied to two blocks of mass 4 kg and 2 kg on a frictionless horizontal surface as shown in the diagram.



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

v. A plastic jug is filled with ice at -25°C and heated at a constant rate over a bunsen. The temperature (T) versus time (t) graph is shown below



In which part/s of the graph is there a change of state?

A. only A B. only B C. only C D. only D
E. A and C F. B and D G. A, B, C and D

QUESTION 1 (contd.) Marks

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

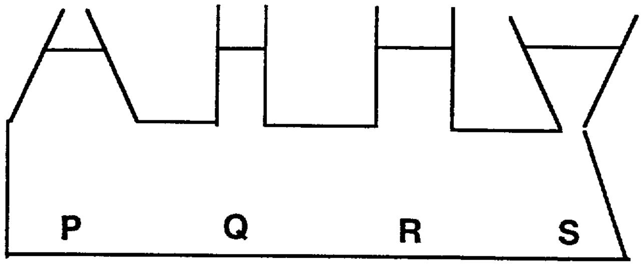
B. 50 °C & 90 °C

C. -10 °C & 30 °C

D. 30 °C & 60 °C

Along which rod does heat flow at the slowest rate - A,B,C or D?
Answer E if you think the heat flows at the same rate for each rod.

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



What are the relative pressures at P,Q, R &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.

viii. 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

10

QUESTION 1 (contd.) **Marks**

b. i. A student decided to determine, g, the acceleration due to gravity, using the formula for the period of a pendulum ($T = 2\pi (L/g)^{0.5}$), 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.

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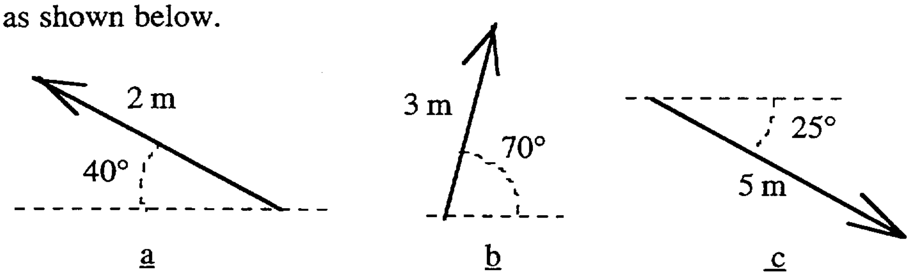
SECTION B

DO ANY 5 QUESTIONS IN THIS SECTION

QUESTION 2.

Marks

a. A body undergoes three displacements. Each displacement is represented by a vector, as shown below.



Calculate the resultant displacement, R (magnitude and direction), where R is given by, $\underline{R} = 2\underline{a} - \underline{b} + \underline{c}$

4

b The relationship between mass, M, and time, t, in a corrosion experiment can be written,

$$M = \sqrt{kt + D}$$

Assuming the equation to be correct, what are the *dimensions* of k and D?

3

c. A wheel of diameter 2.5 m accelerates from rest with an angular acceleration of 0.5 rad s^{-2}. After 6 s has elapsed, what is

i. The angular velocity of the wheel?

ii. The angle through which the wheel has rotated?

iii. The tangential velocity of a point at the edge of the wheel?

iv. The centripetal acceleration of a point at the edge of the wheel?

7

d A ball is thrown from the roof of a building at a velocity of 20 m/s and at an angle of 25° above the horizontal. If the ball begins its motion at a height of 250 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 (give magnitude and direction)?

6

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Question 3. **Marks**

a. A block whose mass M is 8.0 kg is pushed (by a hand) across a frictionless surface by a stick whose length is 1.2 m and whose mass m is 0.65 kg. The block is moved (from rest) a distance d= 43 cm in 1.7 seconds at constant acceleration.

i. Draw a diagram of all the forces acting on the stick and on the block.

ii. What does Newton's Third Law say about the interaction between the stick and the block?

iii. With what force does the stick push on the block?

iv. What force must the hand apply to the stick?

v. What force must the hand apply to the stick to cause the same acceleration, if, instead of being smooth, the surface has a coefficient of friction $\mu_k = 0.2$ and only the block touches the surface?

9

b. An automobile of mass 1800 kg collides with a wall. The automobile approaches the wall at 60.0 km/h and rebounds with a velocity of 3.0 km/h. If the collision lasts for 0.150 s, find the average force exerted on the automobile.

5

c. A uniform board of mass 4.5 kg is supported in a horizontal position by a fulcrum positioned at its centre of mass. A mass of 8.0 kg is positioned on top of the board 1.5 m away from the fulcrum.

i. How far away from the fulcrum must a mass of 6.0 kg be positioned on top of the other side of the board in order to balance the system?

ii. Determine the upward force F_{up} exerted on the board by the fulcrum.

6

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Question 4. **Marks**

a. A ball is thrown straight up from point A with an initial speed, v_i. When it returns to point A it has a final speed v_f. If air resistance is **not** neglected, would you expect the final speed to differ from the initial speed? Explain your answer in terms of energy concepts

3

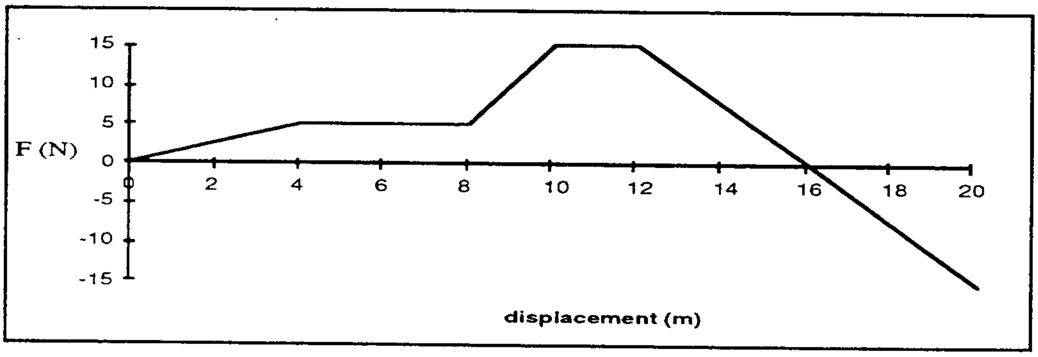
b. A force of 30 N acts on a body of mass 10 kg over a distance of 20 m and then the force is removed. The angle between the force and the displacement is 25°. Assuming that no other forces act in the direction of the displacement, calculate,

i. the work done by the force on the body

ii. the velocity of the body after the body has travelled 45 m, if the body is at rest when the force is applied.

4

c. An object of mass 5 kg moves with a velocity of 6 m s^{-1} when its displacement is zero. The object then experiences a resultant force of varying magnitude which is applied in the direction of its velocity as shown in the diagram below.



i. Calculate the work done by the force on the object over the first 8 m.

ii. What is the kinetic energy of the body when its displacement is 16 m ?

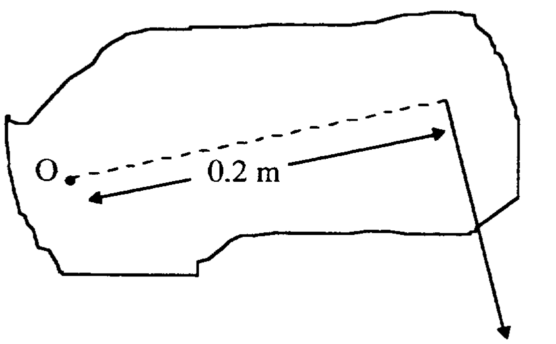
iii. What is the velocity of the body when its displacement is 16 m ?

7

Question 4 (contd.)

Marks

d. Consider the diagram below.



A force of 40 N acts on a body of moment of inertia 15 kg m^2 about O. The body rotates about O, and the force remains tangential to the circle described by the body through one complete revolution and is then removed.

i. Calculate the work done on the body

ii. While the torque is applied, what is the angular acceleration of the body?

iii. If the body rotates from rest, and there are no frictional forces present, what is the angular velocity of the body after the torque has been removed?

6

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Question 5. **Marks**

a. Give an interpretation of temperature based on the kinetic theory of gases.

2

b. The temperature of a metal rod is increased by 120 °C and its length increases by 0.11%. Calculate the coefficient of linear expansion of the metal.

2

c. Heat flows into 0.10 kg of wax at 20 °C. Calculate the amount of heat required to melt half the wax. The melting point of the wax is 70 °C. The specific heat of the wax is 1800 J/kg·K and its heat of fusion is 12 500 J/kg.

4

d. The temperature of the tungsten filament in a 100 W electric light bulb is 2000 °C and its emissivity is 0.4. Find the surface area of the filament if all the electrical energy is converted into electromagnetic radiation.

3

e. Consider a container made of styrofoam. It is filled with water at 10 °C. When the outside temperature is 35 °C, it is found that the temperature of the water increases by 0.2 °C after 600 s. The container is a cube with sides 125 mm and the thickness of its walls is 8 mm. (The density of water is 1000 kg/m^3 and the specific heat of water is 4200 J/kg·K.)

i. Calculate the rate of heat transfer to the water.

ii. Calculate the coefficient of thermal conductivity of styrofoam.

6

f. What is its maximum theoretical efficiency of a heat engine operating between 430°C and 1870°C.?

3

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Question 6. **Marks**

a. i. On a p-V diagram, show the thermal processes involved in a Carnot cycle of a gas.

ii. Why is the Carnot cycle of importance?

3

b. A tank of fixed volume 0.300 m^3 contains 2.00 moles of helium gas at 20.0°C. Assume the helium behaves like an ideal gas.

i. What is the pressure in the gas?

ii. How would this pressure be altered if the temperature is raised from 20.0°C to 100.0°C?

ii. What is the average kinetic energy per molecule at 20 °C?

iii. Determine the root-mean-square speed of the helium atoms at 20.0°C. ($M_{He} = 4$)

7

c. A uniform mass of 23.7 kg is supported by two identical 1.83 m copper wires (Young's Modulus = 1.23×10^{11} Nm^{-2}, Ultimate Strength = 3.8×10^{8} N m^{-2}), one at each end. If the diameter of each wire is 3.1 mm, determine

i. the amount each wire stretches

If 10% of the Ultimate Strength must not be exceeded, determine

ii. the greatest mass that the two wires could support.

5

d. i. Explain why an iceberg floats, and

ii. calculate the fraction of the total volume of an iceberg **above** the water?

The density of ice is 920 kg m^{-3} and the density of seawater is 1030 kg m^{-3}.

5

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QUESTION 7. **Marks**

a. A mercury barometer reads 759.8 mm. (density of mercury = 13,550 kg m^{-3})

i. What is the atmospheric pressure in pascals?

ii. What is the pressure 0.12 m under the surface of water in a beaker.

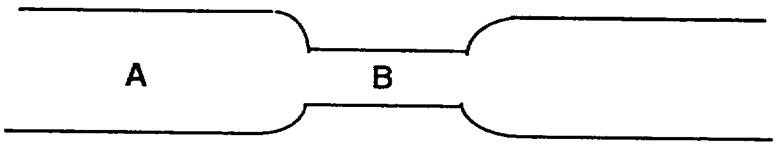
iii. What is the pressure inside an air bubble of radius 0.13 mm, 0.12 m below the surface, in the beaker in part ii.

iv. Briefly comment on what will happen to the air bubble as the water in the beaker is heated.

(for water, density = 1000 kgm^{-3}, surface tension = 7.2×10^{-2} N m^{-1})

7

b. Air flows through a horizontal pipe AB, as shown in the diagram. At A, the cross sectional area is 2.61×10^{-3} m^2 and at B it is 1.19×10^{-3} m^2. If the flow speed at A is 0.738 ms^{-1}. (density of air = 1.3 kgm^{-3})



Determine

i. the speed of the flow at B.

ii. the volume rate of the flow at B.

iii. the pressure difference between A and B. (Clearly indicate which is the larger pressure)

Measuring the pressure difference across a constriction to determine flow characteristics is used in a special device.

iv. what is the name of the device?

6

c. The smallest particles of pollutants (density 2500 kg m^{-3}) emitted from the top of a 100m chimney, take 4 hours to fall to the ground. Assuming the speed with which they leave the top of the chimney is negligible, determine

i. the speed at which these particles fall in ms^{-1};

ii. the diameter of the particles;

iii. the Reynold's Number for the motion of these particles through the air.

iv Explain why calculating the Reynold's Number is important for fluid flow.

(density of air = 1.3 kgm^{-3}, viscosity of air = 2.1×10^{-5} Pa.s)

7

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Mechanics Equation Sheet

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

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

$a = \frac{v^2}{R}$ $\qquad$ $\mathbf{\Gamma} = \mathbf{r} \times \mathbf{F}$ $\qquad$ $\mathbf{\Gamma} = I\boldsymbol{\alpha}$

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

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

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

$P = \mathbf{F} \cdot \mathbf{v}$ $\qquad$ $P = \Gamma\omega$ $\qquad$ $W = \Gamma\theta$

$\mathbf{L} = m\mathbf{r} \times \mathbf{v}$ $\qquad$ $\mathbf{J} = \mathbf{F}\Delta t$ $\qquad$ $\Delta\mathbf{L} = \int \mathbf{\Gamma}\,dt$

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

Dynamics Equation Sheet

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

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

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

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

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

Rotation about fixed axis:

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

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

Thermal Equation Sheet

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

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

$\Delta Q = mc\Delta T$

$\Delta Q = nC\Delta T$

$\Delta Q = mL$

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

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

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

$PV = nRT$

$PV = NkT$

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

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

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

$C_p - C_v = R$

$C_v = \frac{3}{2}R$ (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

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

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

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

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

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

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