Cover Type A

UTS

University of Technology, Sydney

THIS PAPER MAY BE REMOVED FROM THE EXAM CENTRE.

SPRING SEMESTER EXAMINATION 1999

FACULTY OF SCIENCE

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

68101

THURSDAY, 18 NOVEMBER, 1999

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

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. 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 ^oC & 50 ^oC

B. 50 ^oC & 90 ^oC

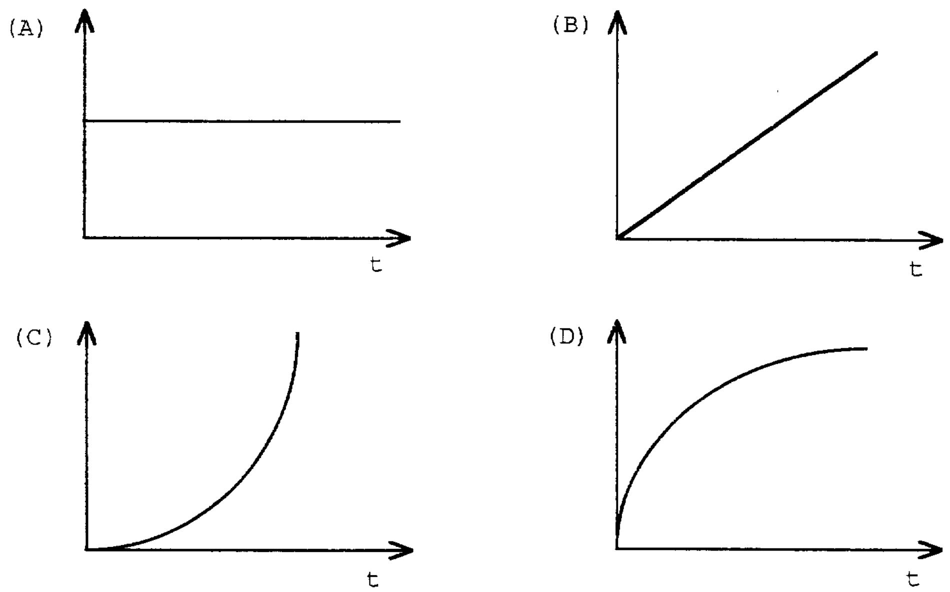
C. -10 ^oC & 30 ^oC

D. 30 ^oC & 60 ^oC

Along which rod does heat flow at the slowest rate?

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

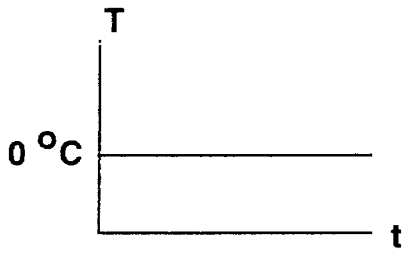
ii. An object is dropping from rest under gravity . Which of the following graphs represents the variation of **velocity** with time?



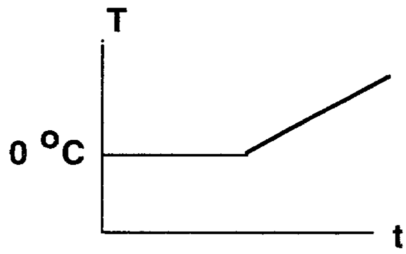
QUESTION 1 (contd.)

iii. A cup contains water at 0 °C but no ice. 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 the water starts to boil?

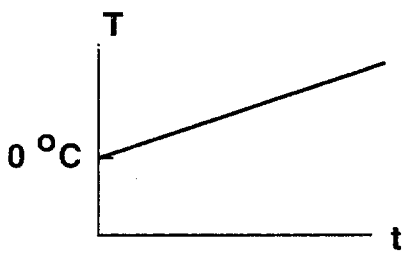
A.



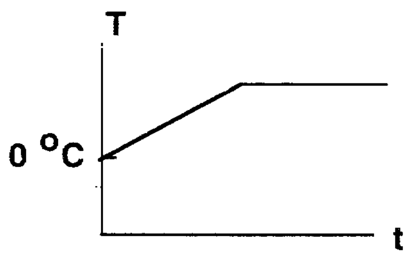
B.



C

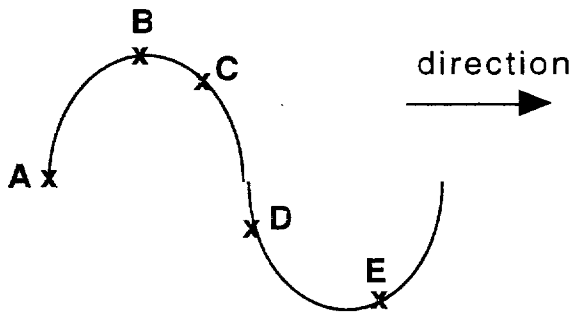


D.



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.

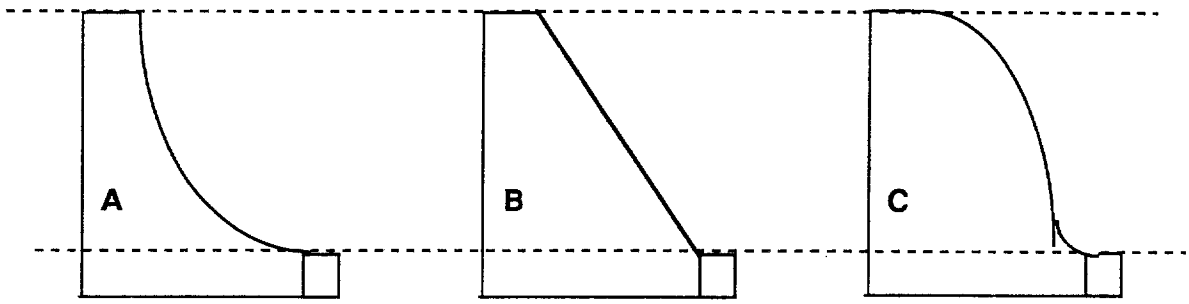
D. Particle D is moving the fastest.

E. Particle E is moving the fastest.

F. All particles are moving at the same speed

QUESTION 1 (contd.)

v. A young girl wishes to select one of the *frictionless* playground slides illustrated below to give her the greatest possible speed when she reaches the bottom of the slide.



Which of the slides illustrated in the diagram above should she choose?

A. Slide A B. Slide B C. Slide C

D. It doesn't matter, her speed would be the same for each slide.

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.

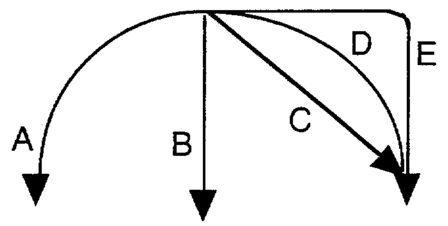
vii. Two identical resistors are connected first in series and then in parallel. Which combination has the larger total resistance?

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

QUESTION 1 (contd.) **Marks**

viii. An object is dropped from a plane flying towards the right in the diagram. What is the path of the object as seen from the ground?

A. B. C. D. E.



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b. In an experiment to determine the density (ρ =M/V) of aluminium a student measured the mass and the volume of 5 aluminium objects of different shapes and obtained the results in the table. An electronic balance and a measuring cylinder was used for the measurements.

object number	shape	M in g (± 0.1g)	V in ml (± 0.5 ml)
1.	sphere	63.5	23.5
2.	cylinder	97.8	35.5
3.	sphere	115.7	43.0
4.	rectangular block	147.2	53.5
5.	irregular shape	188.3	71.0

i. By using the graph paper provided, determine the density of aluminium.

ii. Why do you think the student used 5 objects, when one would have been sufficient to calculate the density of aluminium?

iii. How could the student have obtained a more accurate value for the density of aluminium?

iv. The student also had a large irregular shaped object that wouldn't fit in the measuring cylinder and so she used a spring balance (± 0.1 N) and measured its weight in air and in water (density 1000 kg m^{-3}) and obtained 3.1 N and 2.0 N respectively. Could this object be aluminium? Explain your answer. 10

20

SECTION B

Do any 5 questions in this Section

QUESTION 2. **Marks**

a. There is a relationship between the frequency, f, of waves travelling along a stretched string and

i. the length of the string, L

ii. the tension in the string, T

iii. the mass per unit length of the string, μ

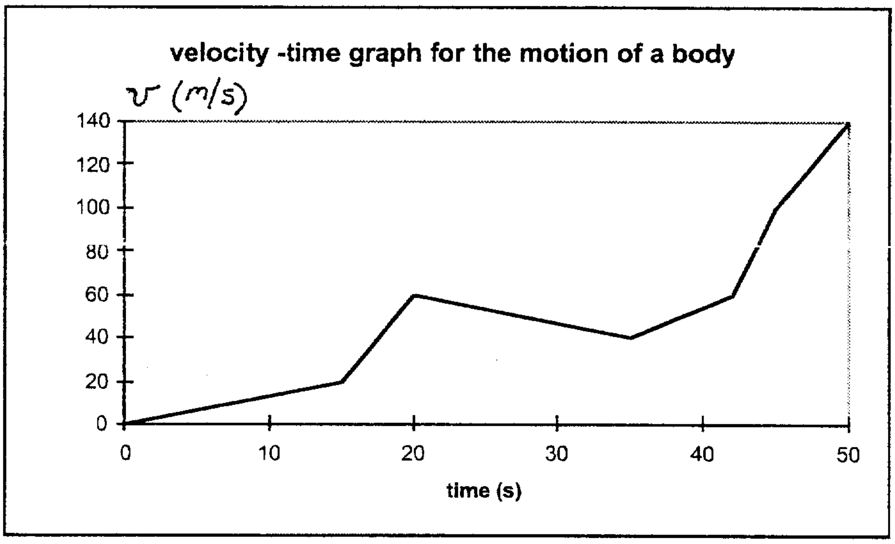
It is suggested that the relationship is,

$$f = \frac{T}{L\mu}$$

Is this equation dimensionally consistent?

4

b. Consider the following graph of velocity in ms^{-1} against time in seconds.



Using the graph above calculate:

i. the acceleration of the body at time = 25 s

ii. the distance travelled by the body between time = 0 s and time = 15 s

iii. the average acceleration of the body between time = 0 s and time = 50 s.

6

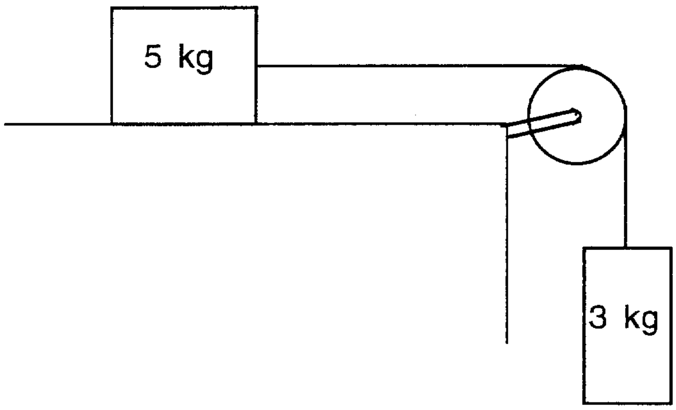
QUESTION 2 (contd.) **Marks**

c. A 5 kg block is on a horizontal, frictionless surface as shown below. The pulley is also frictionless.

   i. Draw a free body diagram showing the forces acting on each block.

   ii. Find the acceleration of the blocks

   iii. Determine the tension in the cord connecting the blocks together



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d. Martina Hinges applies a force of 25 N to a tennis ball of mass 60 g for 0.1 s. Assuming the ball is initially at rest, calculate,

   i. the momentum of the ball at the instant it leaves the racket

   ii. the velocity of the ball at that instant

4

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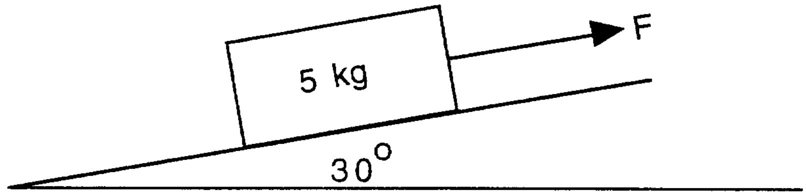
Marks

QUESTION 3.

a. Consider the body below which is accelerating up a plane inclined at 30° to the horizontal.



If the coefficient of kinetic friction, $\mu_k = 0.2$ and F = 40 N, what is the acceleration of the 5 kg body up the plane ?

4

b. A force applied to a body, $\underset{\sim}{F}$, and the displacement of the body, $\underset{\sim}{s}$, are represented by

$\underset{\sim}{F} = -3\underset{\sim}{i} + 6\underset{\sim}{j}$ (unit N) and

$\underset{\sim}{s} = 6\underset{\sim}{i} - 8\underset{\sim}{j}$ (unit m)

What is the angle between $\underset{\sim}{F}$ and $\underset{\sim}{s}$?

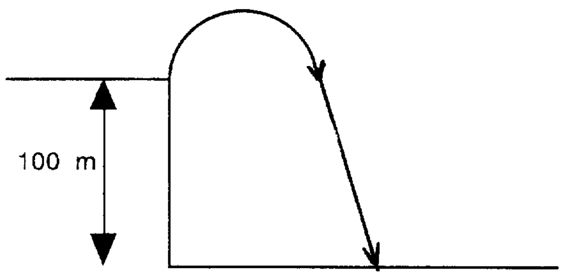
3

c. A ball is thrown from the roof of a building at a velocity of 50 m/s and at an angle of 65° above the horizontal. If the ball begins its motion at a height of 100 m above the ground,

i. what is the ball's maximum height above the ground ?

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

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



6

QUESTION 3 (contd.) **Marks**

d. i. With the aid of examples, distinguish between elastic and inelastic collisions.

ii. A body of mass 6 kg travelling in the $+x$ direction with an initial velocity of 20 m/s collides elastically with another body of mass 3 kg which initially is at rest. Calculate the final velocity of each body.

7

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QUESTION 4.

Marks

a. Two ships moving in parallel must maintain a certain minimum separation for fear of collision. Explain, in terms of fluid dynamics, how such a collision may occur.

3

b. In *tug of war*, two teams pull at the opposite ends of a rope. When each team applies a force of 1,500 N, the rope (5.0 m long and 0.0025 m^2 in cross-section) stretches 5.0 cm. What is the stress, the strain, and Young's modulus for the rope?

5

c. A sealed empty box of mass 200 kg, forming a cube of side 1 m, is lowered in water. The density of water is 10^3 $kg.m^{-3}$. What proportion of the volume of the box will be under water?

6

d. A boy throws a spherical stone (of diameter 15.3 mm) vertically into the air and it reaches a height of 15.1 m. Assume the density of air is zero and its viscosity 1.8×10^{-5} $kg.m^{-1}s^{-1}$.

i. What is the terminal velocity for the stone?

ii. Will the stone ever reach its terminal velocity as it falls? Show your reasoning.

6

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QUESTION 5. **Marks**

a. The coefficient of linear expansion of glass is $8.3 \times 10^{-6}\,K^{-1}$. A rod of glass of length 250.00 mm at 20 °C is heated to 100 °C. What is its length at 100 °C?

3

b. 25 g of <u>ice</u> at 0 °C is put into a cup containing 350 g of water at 90 °C. Assuming no heat losses occur, what is the final temperature of the water?

latent heat of fusion of ice = 3.33×10^{5} J.kg^{-1}

specific heat capacity of water = 4186 J.kg^{-1}.K^{-1}

4

c. Describe briefly three ways in which heat may be transferred to or from a body.

3

d. i. Write down the ideal gas equation. Explain clearly what each symbol in your equation represents.

ii. The pressure of gas in a constant-volume gas thermometer is 1.5×10^{4} Pa when immersed in a bath of water at its triple point. What is the temperature when the pressure of gas in the thermometer is 2.05×10^{4} Pa ? (Take the temperature of the triple point of water = 0.01 °C).

iii. What pressure in the thermometer corresponds to a temperature of 30 °C ?

7

e. What is the root-mean square speed of a nitrogen molecules (*Molecular weight* = 28 g/mol), when the molecules are at a temperature of 30 °C ?

3

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QUESTION 6. **Marks**

a. Define, in words, the simple harmonic motion. 3

b. A transverse wave moving on the sea surface makes a 30 kg buoy bob up and down with a simple harmonic motion of period 1.0 s and amplitude 50 cm.

i. Sketch the buoy's position *y* as a function of time *t*.

ii. Sketch (qualitatively) the buoy's kinetic energy K as a function of time *t*.

Another buoy, 2.5 m away, is exactly out of phase with the first buoy.

iii. What is the longest possible wavelength of the ocean wave?

iv. What is its velocity? 8

c. Noise suppression can sometimes be achieved by emitting a sound wave that annuls (cancels) the noise. The noise wave is given, in metres, by

$$y = 0.002\sin[2\pi(10^4 t - 30x)].$$

i. What is the equation of motion of the annulling wave?

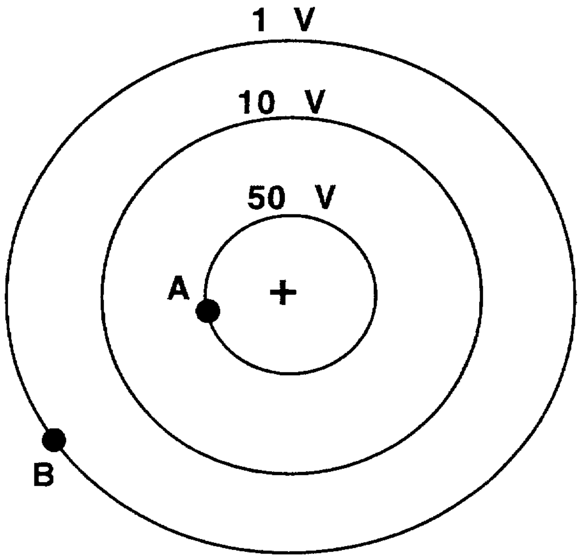
ii. What is the frequency and the wavelength of the annulling wave? 5

d. A stretched string of length 60 cm is clamped at both ends. As it vibrates, no motion is observed at 3 points (nodes). What is the wavelength of the wave? 4

20

QUESTION 7. **Marks**

a. The figure below shows the 1V, 10V and 50 V equipotentials around a positive point charge.



How much work is done on a charge of $+1.5 \times 10^{-11}$ C in moving that charge from A to B ?

3

b. A filament bulb has a resistance of 2 Ω when unheated. When lit, its resistance is 20 Ω. By how much does the temperature of the tungsten filament increase when the bulb is lit. (temperature coefficient of resistance of tungsten is 4.5×10^{-3} °C^{-1})

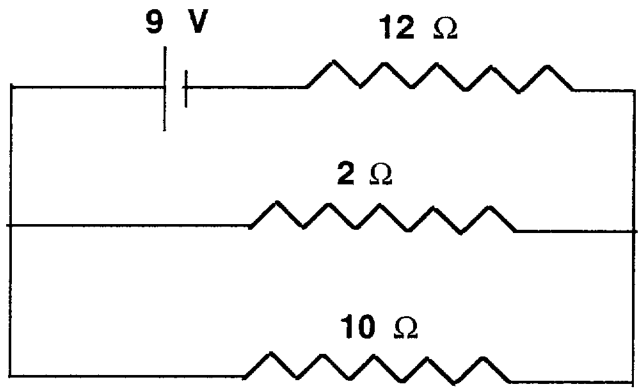
5

c. State Ohm's law

2

QUESTION 7 (contd.) Marks

d. i. Determine the current through each resistor in the circuit below.



ii. If a 24 Ω resistor were placed in parallel with the 12 Ω resistor in the circuit above, what would be the current through the 2 Ω resistor?

6

e. The power dissipated in a wire of resistance 12 Ω is 0.48 W. If the wire has a diameter of 1.2 mm, calculate:

i. the voltage across the wire
ii. the current density through the wire
iii. the energy dissipated in the wire in 5 minutes

4

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-)

$Q = W + \Delta U$

$\Delta U = nC_v\Delta T$

$W = P\,(V_f - V_i)$

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

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

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

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

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

Properties of Matter/Fluids Equation Sheet

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$V = \frac{q}{4\pi\varepsilon_0 r}$

$E = \frac{q}{4\pi\varepsilon_o r^2}$

$U = \frac{q_1 q_2}{4\pi\varepsilon_o r}$

$E = -\frac{dV}{dx}$

$C = \frac{\varepsilon_0 A}{d}$

$U_E = \frac{1}{2}CV^2$

$W = \frac{QV}{2}$

$W = VIt$

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

$\oint \underset{\sim}{E}.d\underset{\sim}{A} = \frac{q}{\varepsilon_o}$

$\underset{\sim}{F} = q\underset{\sim}{v} \times \underset{\sim}{B}$

$\underset{\sim}{F} = i\underset{\sim}{l} \times \underset{\sim}{B}$

$\underset{\sim}{M} = i\underset{\sim}{A}$

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

$\frac{F}{\ell} = \frac{\mu_o I_1 I_2}{2\pi a}$

$\oint \underset{\sim}{B}.d\underset{\sim}{l} = \mu_0 I$

$dB = \frac{\mu_0 i\, dl \sin\theta}{4\pi r^2}$

$\phi_B = \int \underset{\sim}{B}.d\underset{\sim}{A}$

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

$\varepsilon = -L\frac{di}{dt}$

$\varepsilon = -M\frac{di}{dt}$

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

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

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

$\tau = RC$

$X_L = \omega L$

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

$Z^2 = R^2 + (X_L - X_C)^2$

$\tan\phi = \frac{X_L - X_C}{R}$