



The University of Zambia
Physics Department
PHY1010: Introductory Physics
Term Test-III July 2014

Time: Two hours.

Maximum marks = 100.

Question 1 is compulsory. Attempt only three more questions. All questions carry equal marks. The marks are shown in square brackets. Clearly indicate on the cover page of the answer script which questions you have attempted.

Write clearly your name, computer number, and tutorial group number on the answer book. Show your working clearly. Omission of essential work will lead to loss of marks.

=====
Wherever necessary use:

$$g = 9.8 \text{ m/s}^2 : \rho_{\text{water}} = 1000 \text{ kg/m}^3 : 1 \text{ hp} = 746 \text{ watts} : 1 \text{ ton} = 1000 \text{ kg} : 1 \text{ cal} = 4.184 \text{ J}$$

Some equations you may find useful:

$$x = v_{\text{avg}} t : v_f = v_0 + at : v_f^2 = v_0^2 + 2ax : x = v_0 t + \frac{1}{2} at^2 : W = mg : \mathbf{p} = m\mathbf{v}$$

$$f = \mu F_N : Ft = \Delta p = m(v_f - v_0) : \text{work} = Fs \cos \theta : \text{K.E.} = (1/2)mv^2 : F = ma$$

$$\text{G.P.E.} = mgh : \text{power} = \text{work/time} = Fv : \Delta PE + \Delta KE + \Delta TE = 0$$

$$R = \frac{2u^2 \sin \theta \cos \theta}{g} = \frac{u^2 \sin 2\theta}{g} : y = x \tan \theta - \frac{g}{2v_0^2 \cos^2 \theta} x^2 : t = \frac{2u \sin \theta}{g} : v_{\text{avg}} = \frac{v_f + v_0}{2}$$

$$v_T = \omega r : \omega_f = \omega_0 + \alpha t : \omega_f^2 = \omega_0^2 + 2\alpha\theta : \theta = \omega_0 t + \frac{1}{2} \alpha t^2 : F_c = (mv^2 / r) : I = mk^2 : a_T = \alpha r :$$

$$L = I\omega : \tau = I\alpha = Fr : v_T = (2\pi r) / T : \tan \theta = v^2 / rg : I = \sum mr^2 : \text{KE}_{\text{rot}} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 :$$

$$1 \text{ rev} = 360^\circ = 2\pi \text{ rad} : F = G \frac{m_1 m_2}{r^2} : \text{volume of a sphere} = \frac{4}{3} \pi r^3 : \left[\frac{1}{2} mv^2 \right]_{\text{avg}} = \frac{3}{2} kT$$

$$Y = \frac{F/A}{\Delta L/L_0} : B = -\frac{\Delta P}{\Delta V/V_0} : P = \rho gh : W_{\text{app}} = mg - B.F. : W_{\text{app}} = W \left[1 - \frac{\rho_f}{\rho} \right]$$

$$\Delta Q = mc\Delta T = nC\Delta T : \Delta L = \alpha L\Delta T : \Delta V = \gamma V\Delta T : \Delta W = P\Delta V : PV = nRT : P_1 V_1^\gamma = P_2 V_2^\gamma$$

$$(\Delta Q / \Delta t) = (k\Delta T) / \Delta L : \Delta Q = \Delta U + \Delta W :$$

For Question 1, you **must use the blank answer sheet** provided.

For other questions, clearly indicate which one you are attempting:

Example:

Question 2(b)

DO NOT write the question number in the top left corner of the page, and then staple over it!! To mark it we have to see it. Organize the answer script properly before stapling it.

Question 1: Sample answers: F(a), G(d)... etc. For each correct answer, 2.5 marks.

For each wrong answer, (0.83) will be deducted. No answer, zero mark.

No deduction of marks for not attempting. Minimum total mark for Question 1 is zero.

So don't be afraid to attempt!!

[10 × 2.5 = 25]

(A) The stress on a wire supporting a load does not depend on:

- (a) the acceleration of gravity
- (b) the wire's diameter
- (c) the mass of the load
- (d) the wire's length

(B) When stretched beyond its elastic limit, a metal rod such as steel:

- (a) becomes plastic
- (b) becomes elastic
- (c) obeys Hooke's law
- (d) becomes colder.

(C) A cake of soap placed in a bathtub of water sinks. The buoyant force on the soap is:

- (a) equal to its weight
- (b) more than its weight
- (c) zero
- (d) less than its weight

(D) At normal temperature and pressure water boils at 100°C. At the bottom of a deep mine, water will boil at a temperature of:

- (a) 100°C
- (b) greater than 100°C
- (c) less than 100°C
- (d) will not boil at all.

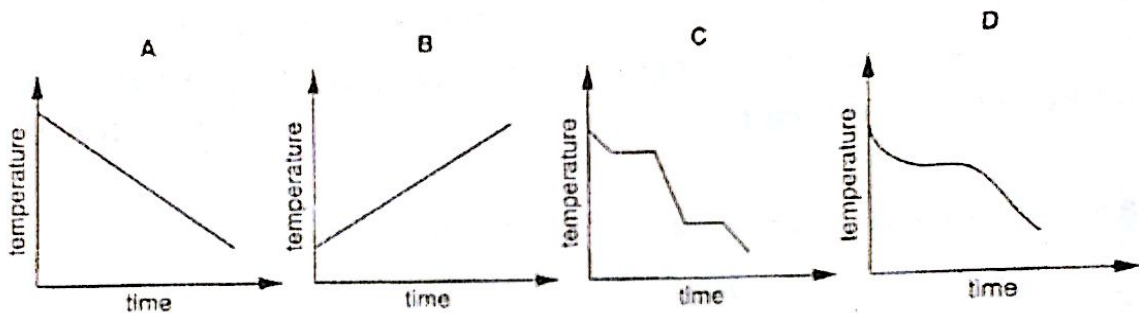
(E) When a gas is in equilibrium, its molecules:

- (a) all have the same energy
- (b) have different energies that remain constant
- (c) have a certain constant average energy
- (d) do not collide with one another.

(F) Evaporation cools a liquid because:

- (a) the slowest molecules tend to escape
- (b) the pressure on the liquid increases
- (c) the pressure on the liquid decreases
- (d) the fastest molecules tend to escape.

(G) Which graph shows the change in temperature as steam at 110°C is cooled to -10°C ?



(H) The work output of every heat engine:

- (a) depends only on its intake temperature
- (b) equals the difference between its heat intake and heat exhaust
- (c) depends only on its exhaust temperature
- (d) equals that of a Carnot engine with the same intake and exhaust temperatures.

(I) An ideal heat engine can be 100% efficient only if its exhaust temperature is:

- (a) equal to its input temperature
- (b) zero K
- (c) 0°C
- (d) less than its input temperature.

(J) The internal energy of an ideal gas depends only on:

- (a) temperature
- (b) pressure
- (c) volume
- (d) both temperature and volume.

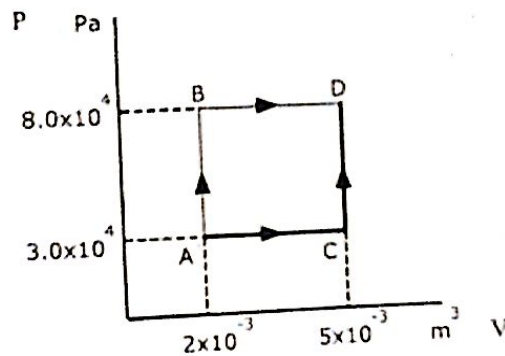
Answer three (3) more questions only from below. If you attempt ALL of them, we may ignore the LAST question attempted:

Q2(a). A steel cable whose cross-sectional area is 2.5cm^2 supports a 1000kg elevator. The elastic limit (maximum stress that can be applied) of the cable is $3.0 \times 10^8 \text{ Pa}$. What is the maximum upward acceleration that can be given to the elevator if the tension in the cable is to be no more than 20% of the elastic limit? [6]

(b) A series of thermodynamic processes is shown in the P - V diagram below. In the process AB , 150 J of heat is added to the system, and the process BD , 600 J of heat is added.

Find:

- i) The change in internal energy in the process AB ;
- ii) The change in internal energy in the process ABD shown with a thin line;
- iii) The total heat added in the process ACD shown with a bold line. [13]



(c) You are given an aluminium wire and a steel wire each of length 80cm at 20°C . The aluminium wire is heated to a temperature of 150°C . To what temperature should the steel wire be heated so that its length becomes the same as that of the aluminium wire at 150°C ? Given $\alpha_{Al} = 25 \times 10^{-6}/^\circ\text{C}$ and $\alpha_{steel} = 12 \times 10^{-6}/^\circ\text{C}$. [6]

Q3(a) (i) Calculate the amount of heat required to convert 5g of ice at -15°C to steam at 120°C . Given $c_{ice} = 0.5 \text{ cal/g}^\circ\text{C}$, $c_{steam} = 0.46 \text{ cal/g}^\circ\text{C}$, $H_f = 80 \text{ cal/g}$, $H_v = 539 \text{ cal/g}$. [8] $1 \text{ cal/g}^\circ\text{C}^{-1}$

(ii) If the amount of heat in (i) above is given to a block of copper of mass 150g at 20°C , what will be its final temperature? Given $c_{cu} = 0.093 \text{ cal/g}^\circ\text{C}$. [7]

(b) A container with an initial volume of 60 litres holds 2.5 moles of a monatomic gas at a temperature of 40°C . The gas is compressed adiabatically to a volume of 32 litres.

Find:

- i) the final pressure, and
- ii) the final temperature of the gas. [10]

Q4(a) A fish at a depth of 10m in a fresh-water lake exhales an air bubble of volume V_0 . Let the temperature of the water at the surface be 25°C and that at 10m depth be 20°C . Find the volume of the bubble just before it reaches the surface. [8]

(b) An engine operates between temperatures of 200°C and surrounding temperature of 20°C . It is operating at 40% of its ideal Carnot efficiency. The engine does a work of 8000J each cycle. Calculate

- (i) The actual efficiency of the engine.
- (ii) The amount of thermal energy absorbed per cycle at the high temperature reservoir.
- (iii) The amount of exhaust thermal energy to the surrounding during each cycle. [9]

(c) Water is confined in a strong container by means of a piston with a cross sectional area of 0.50cm^2 . How large a force on the piston is required to decrease the volume of water by 0.01 percent? Bulk modulus of water is $2.2 \times 10^9 \text{N/m}^2$. [8]

Q5(a) A piece of wood of volume 0.60m^3 and density 600kg/m^3 floats in water. Given, $\rho_{\text{water}} = 1000 \text{kg/m}^3$.

Find:

- i) the volume exposed, and
- ii) the additional force required to immerse it completely under water. [9]

(b) The interior dimensions of a cubical soft drink cooler are $20 \times 20 \times 20 \text{cm}$. Each wall is 5 cm thick and is made of plastic of coefficient of thermal conductivity k . Ice inside the box maintains the interior temperature at 0°C while the outside temperature is 25°C . If 100g of ice melts in one hour, find the value of k . $H_f = 80 \text{cal/g}$ [10]

(c) A cylindrical rod 4cm in diameter and 80cm long at a temperature of 20°C is heated to 100°C and is prevented from expanding by keeping its two ends fixed. Find the force the rod exerts at the two ends at 100°C if the coefficient of linear expansion of steel is $0.000012/^{\circ}\text{C}$ and Young Modulus = $2.0 \times 10^{11} \text{Pa}$. [6]