The University of Zambia
Physics Department
University Examinations 2014-15
PHY 1010: Introductory Physics

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt four more questions. Clearly indicate on the answer script left column on the cover page the questions you have answered.

Time : Three hours. **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book as well as on the answer sheet for Question 1. Tie them together.

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Wherever necessary use:

$g = 9.8 m/s^2$ 1 metric ton = 1000 kg

$P_A = 1.01 \times 10^5$ N/m²

1 cal. = 4.18 J

$C_{water} = 4184$ J/kg.°C

$R = 8314$ J/kmol.K

$k = 1.381 \times 10^{-23}$ J/K (Bolzmann's constant)

$\varepsilon_0 = 8.85 \times 10^{-12}$ C²/Nm²

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ J-s

1 pascal =1 N/m²

1eV = 1.6×10^{-19} J

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

$k = 9 \times 10^9$ Nm²/C²

$\mu_0 = 4\pi \times 10^{-7}$ N/A²

$\rho_{water} = 1000$ kg/m³

$G = 6.67 \times 10^{-11}$ Nm²/kg²

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Answer sheet for Question 1

Computer Number only .....

Q1. Put a cross (×) or tick mark (√) in the appropriate box.
If it is on the dividing line, it will not be counted.

	a	b	c	d
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				

Do NOT write here.
For official use only:

	Number of parts N	Factor f	Marks f × N
Correct		2	
Wrong		–(0.67)	
	Net Marks:		

Attach this sheet firmly with the main answer book. If you lose this sheet, you will lose the marks for Question 1!!

Question 1 : For each correct answer, 2 marks will be given. For each wrong answer, 0.67 will be deducted. For no answer, zero mark will be given. The minimum total mark for Question 1 is zero.]

(A) Periodic motion is a motion:

a) under the influence of an elastic restoring force:
b) that repeats itself in equal intervals of time.
c) back and forth over varying paths
d) with constant acceleration

(B) An ideal gas is heated at constant volume from 300 K to 600 K. If the original pressure was 1.5 atm, the new pressure will be:

a) doubled
b) halved
c) less than doubled
d) the same

(C) At constant temperature the pressure and volume of a gas are:

a) inversely proportional
b) independent of one another
c) directly proportional
d) constant

(D) A modulus of elasticity is a ratio of:

a) stress to deformation
b) stress to strain
c) strain to stress
d) elongation to deformation

(E) The product of force times the perpendicular distance between some point and the line of application of the force is:

a) the moment of inertia acting on the object
b) the angular momentum of the object
c) torque
d) lever arm

(F) An astronaut whose total mass is 100 kg ejects 1.0 g of gas from his propulsion pistol at a speed of 50 m/s. His recoil speed is:

a) 0.5 m/s
b) 5×10^{-4} m/s
c) 5×10^{-3} m/s
d) 5×10^{-2} m/s

(G) A Carnot engine has the same efficiency between 100 K and 500 K as between T K and 1000 K, T being the lower temperature (cold reservoir). The value of T is:

a) 100 K
b) 500 K
c) 200 K
d) 300 K

(H) An acceleration which is constant in time results in a velocity which is:

a) depends inversely on time
b) is a quadratic function of time
c) changes linearly with time
d) remains constant

(I) A vector quantity defined as a change in velocity of a moving object during a given time interval divided by the time interval is:

a) average speed
b) average velocity
c) instantaneous acceleration
d) average acceleration

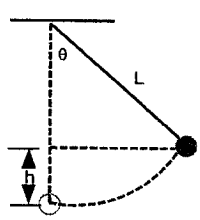
(J) Two boys are standing at the edge of a vertical cliff. One boy fires an air-gun pellet horizontally at the same time the second boy drops a pellet at the edge of the cliff. The shot pellet and the dropped pellet start at the same height from the bottom of the cliff. The time taken for the pellets to reach the ground:

a) is greater for the one shot off the cliff horizontally
b) depends on the initial velocity of the one shot off the cliff
c) is shorter for the one shot off the cliff horizontally
d) is the same for both

Attempt any four questions from the following:

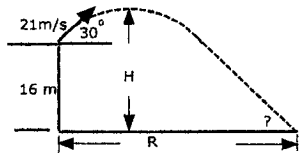
Q 2 (a) A ball at the end of a 2.0 m long string swings in an arc as shown below. The ball's speed is 3.5 m/s as it passes through its lowest position.

i) To what height h above this position will it rise before stopping?
ii) What angle does the string make with the vertical when ball is a at the highest position? **[9]**



(b) A stone is thrown at a velocity of 21 m/s at 30° aboe the horizontal from the top of a building 16 m high as shown below. Find:

i) the time of flight,
ii) the horizontal range, and
iii) the maximum height *H* from the ground. **[11]**



Q.3 (a) An ideal refrigerator, which is Carnot engine operating in reverse, operates between a freezer temperature of -9 °C and a room temperature at 25 °C. In a period of time, it absorbs 120 J from the freezer compartment. How much heat is rejected to the room? **[10]**

(b) A hoop of radius 0.06 m starts from rest and rolls down a slope without slipping.

i) Find its linear and angular speed when it reaches a point 0.50 m vertically lower than its starting point. ($I = mr^2$)
ii) Find the linear and angular speed in (i) above if the slope were perfectly smooth so that the hoop just slipped and does not roll. **[10]**

Q.4(a) A pool ball *A* of mass m_a = 0.400 kg moving with a speed of v_a = 1.8 m/s along the positive *x*-axis strikes another ball *B* initially at rest of mass m_b = 0.500 kg. The collision results in ball *A* being deflected off at an angle of 30° with respect to the positive *x*-axis with a speed of 1.10 m/s.

i) Write down the equations expressing the conservation of momentum in the *x* and *y* directions separately.
ii) Solve the equations for the speed of ball *B* after the collision and the angle θ_b. **[10]**

(b) A car of mass 100 kg moving at 20 m/s on a horizontal road is brought to rest by braking over a distance of 25 m.

i) Find the average braking force.
ii) Now the same car moves up a slope with the same velocity. The slope rises by 1 m for a horizontal distance of 20 m. The retarding force exerted by the slope on the car is 100 N. Find the power which the engine develops. **[10]**

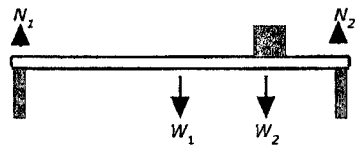
Q.5 (a) Steam flows into a condenser at the rate of 5 m^3/min. The density of steam is 1.50 kg/m^3 and its input temperature is 160 °C. The steam is cooled to 100 °C and then condensed into water at 100 °C. The specific heat capacity of steam is 0.48 cal/g.°C and the heat of vaporization is 540 cal/g. Calculate the amount of heat added to the condenser each minute. **[9]**

(b) A sample of air is compressed from a pressure of 2 atm to 5 atm. The original volume and temperature are 20 litres and 17 °C respectively. Next the air is expanded back adiabatically to its original pressure of 2 atm. Find the final volume (in litres) and the temperature of the gas. (Take air to be essentially composed of oxygen and nitrogen only) **[8]**

(c) Explain the three modes of heat transfer. **[3]**

Q.6 (a) Find the resultant of the following two displacements: 1 m along the positive *x*-axis, 2 m at 40° and 4 m at 127°; the angles being relative to the positive *x*-axis. **[10]**

(b) A uniform bar of weight W_1 = 35 N is supported at its ends as shown below. A block of weight W_2 = 10 N is placed one quarter distance from one end. What are the magnitudes of the forces N_1 and N_2 exerted by the supports?



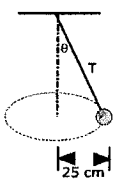
[10]

Q.7 (a) A man slides a crate at constant velocity along a horizontal floor by pulling on a rope attached to the crate at an angle of 30° to the horizontal. The crate weighs 50 kg and the coefficient of kinetic friction between the crate and the floor is 0.65. Find the tension exerted on the rope. **[10]**

(b) A horizontal spring with a force constant *k* of 1300 Nm^{-1} attached to a wall is connected to a 3 kg mass resting on a frictionless surface. The mass is pulled a distance of 2.5 cm and released. Calculate:

i) The frequency of oscillation
ii) The maximum speed of the mass
iii) The maximum acceleration of the mass
iv) The speed of the mass when the spring is compressed by 1 cm. **[10]**

Q.8 (a) A small sphere of mass 0.5 g is suspended by a string 50 cm long, with the string kept taut, the ball is whirled in a horizontal circle of radius 25 cm. Calculate its angular speed in radians per second. **[10]**



(b) A piece of wood of volume 0.6 m^3 floats in water. Find the volume of the wood outside the water. What additional force is required to immerse it completely under water. The density of the wood is 600 kg/m^3. **[10]**

END OF EXAMINATION

Some Useful Equations

Uniformly accelerated motion:

$x = \bar{v}t \qquad \bar{v} = \frac{1}{2}(v_f + v_i) \qquad v_f = v_i + at \qquad v_f^2 = v_i^2 + 2ax \qquad x = v_i t + \frac{1}{2}at^2$

Projectile motion:

$v_x = v_i \cos\theta_i = \text{constant} \qquad v_y = v_i \sin\theta_i - gt \qquad y = (v_i \sin\theta_i)t - \frac{1}{2}gt^2$

$y = (\tan\theta_i)x - \left[\frac{g}{2v_i^2(\cos^2\theta_i)}\right]x^2 \qquad R = \frac{v_i^2}{g}\sin 2\theta \qquad t = \frac{2v_i \sin\theta}{g}$

Force and motion:

$F = ma \qquad w = mg \qquad F_{AB} = -F_{BA} \qquad F_f = \mu F_N$

Energy:

$PE = wh = mgh \qquad KE = \frac{1}{2}mv^2 \qquad W = Fx\cos\theta \qquad P = \frac{W}{t} = Fv\cos\theta$

Linear momentum:

$p = mv \qquad F\Delta t = \Delta mv$

Circular motion and gravitation:

$T = \frac{2\pi r}{v} \qquad a_c = \frac{v^2}{r} \qquad F_c = \frac{mv^2}{r} \qquad F_{grav} = G\frac{m_A m_B}{r^2} \qquad 1rev = 360^0 = 2\pi\, rad$

Rotational motion and angular momentum:

$\theta = \frac{s}{r} = \left(\frac{\omega_i + \omega_f}{2}\right)t \qquad \omega = \frac{\theta}{t} \qquad \theta = \omega_i t + \frac{1}{2}\alpha t^2 \qquad \omega_f = \omega_i + \alpha t$

$v = \omega r \qquad \omega_f^2 = \omega_i^2 + 2\alpha\theta \qquad \alpha = \frac{\Delta\omega}{\Delta t} = \frac{a_T}{r} \qquad I = \sum mr^2 \qquad I = mk^2$

$KE_{rot} = \frac{1}{2}I\omega^2 \qquad \tau = FL = I\alpha \qquad W = \tau\theta \qquad P = \tau\omega \qquad L = I\omega$