



The University of Zambia  
School of Natural Sciences  
Department of Physics  
2022/23 Academic Year  
Introductory Physics: PHY 1010

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 cover page which questions you have attempted.

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!!

Wherever necessary use:

$$g = 9.8 \text{ m/s}^2$$

$$P_A = 1.01 \times 10^5 \text{ N/m}^2$$

$$1 \text{ cal.} = 4.18 \text{ J}$$

$$\rho_{\text{water}} = 1000 \text{ kg/m}^3$$

$$1 \text{ hp} = 746 \text{ W}$$

$$1 \text{ Pascal} = 1 \text{ N/m}^2$$

$$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

$$1 \text{ metric ton} = 1000 \text{ kg}$$

**Question 1:** Sample answers: F (a), G (d)... etc. **DO NOT guess** the answer. For each correct answer, **2 marks** are given. For each wrong answer, **0.67** will be deducted. For no answer, zero mark. The minimum total mark for Question 1 is zero. [10 × 2 = 20]

- (A) A ball dropped loses potential energy. Gravity is an example of:
- (a) a non conservative force.
  - (b) a conservative force.
  - (c) dissipative force.
  - (d) any of the above, depending on the reference level.

- (B) The magnitude of the resultant of two forces is a minimum when the angle between them is.

- (a) 0                      (b) 45                      (c) 90°                      (d) 180°

- (C) The acceleration of gravity on planet Mars is 3.7 m/s<sup>2</sup>. Compared with her mass and weight on Earth, an astronaut on Mars has:

- (a) less mass and less weight.
- (b) less mass and more weight.
- (c) the same mass and less weight.
- (d) less mass and the same weight.

- (D) The coefficient of friction is defined as:

- (a) the ratio of the force needed to induce motion to the force needed to maintain motion.
- (b) the ratio of the pressure to the force pressing the surfaces together.
- (c) the ratio of the frictional force to the normal force.
- (d) the ratio of the normal force to the frictional force.

- (E) An 800 kg car moving at 80 km/hr collides with a 1200 kg car moving at 40 km/hr in the same direction. If the two cars stick together, the wreckage has an initial speed of?

- (a) 8 km/hr
- (b) 56 km/hr
- (c) 40 km/hr
- (d) 60 km/hr

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f$$

$$800 \times 22.2222 + 1200 \times 11.1111 = (800 + 1200) v_f$$

$$51111.092 = \frac{2000 v_f}{2000}$$

$$15.5 \text{ m/s}$$

$$\frac{80 \text{ km}}{\text{hr}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

$$22.2222 \text{ m/s}$$

$$\frac{40 \text{ km}}{\text{hr}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

$$11.1111 \text{ m/s}$$

$$\frac{15.5 \text{ m}}{\text{s}} \times \frac{1 \text{ hr}}{3600 \text{ s}} \times \frac{3600 \text{ s}}{1 \text{ hr}}$$

$$55.8 \text{ km/hr}$$

- (F) When a force acts on an object, the stress on it is equal to:

- (a) Young's modulus
- (b) the relative change in its dimensions
- (c) the elastic limit
- (d) the applied force per unit area

- (G) The moment of inertia of an object does not depend on:

- (a) its size and shape.
- (b) its mass.
- (c) its angular speed.
- (d) the location of the axis of rotation.

$$\mu = \frac{F_f}{F_N}$$

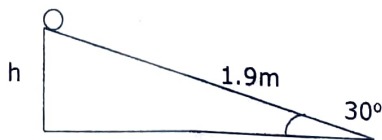
- (H) In an equilibrium problem the point about which torques are computed:
- must pass through the object's centre of gravity.
  - may be located anywhere.
  - must pass through one end of the object.
  - must intersect the line of action of at least one force acting on the object.
- (I) The pressure at the bottom of a vessel filled with a liquid does **not** depend on the:
- liquid density
  - acceleration due to gravity
  - height of the liquid
  - area of the liquid surface
- (J) When an ox pulls a wagon, the force that allows the ox to move forward is the force
- the ground exerts on it
  - it exerts on the wagon
  - it exerts on the ground
  - the wagon exerts on it

**ATTEMPT ANY FOUR QUESTIONS FROM BELOW:**

**Q.2 (a)** A vector **A** has a magnitude of 30 m at an angle of  $200^\circ$  with respect to the positive x-axis. If we add a vector **B**, it is found that the resultant is along the positive x-axis and has magnitude of 10 m, what are the components of vector **B** and its direction? [10]

(b) A solid uniform disc with radius 7.5 cm starts from rest and rolls down a frictionless plane 1.9 m long. [ $I_{\text{solid disc}} = \frac{1}{2}mr^2$ ]

- What is its linear speed at the bottom?
- What is its angular velocity (in rad/s)?
- How long does it take to reach the bottom? [10]



**Q.3 (a)** A stone is thrown upward from the top of a building at an angle of  $25^\circ$  to the horizontal level of the roof and with an initial velocity of 15 m/s. If the stone is in flight for 3.0 seconds before hitting the level ground, how tall is the building? [10]

(b) A solid wooden cube, 30 cm on each side, can be totally submerged in water if it is pushed with a downward force of 54.0 N. What is the density of the wood? [8]

$$mgh = \frac{1}{2} I \omega^2$$

$$mgh = \frac{1}{2} \left( \frac{1}{2} m r^2 \right) \omega^2$$

$$\frac{1}{2} m v^2$$

$$ME_o = ME_f$$

$$PE_o + RKE$$

$$PE_o + KE_o + RKE$$

$$PE_o = PE_f + KE_f + RKE_f$$

$$ME_i - ME_f + W_f$$

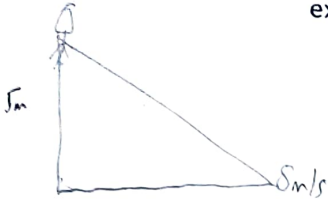
$$mgh = \frac{1}{2}mv^2$$

$$mgl$$

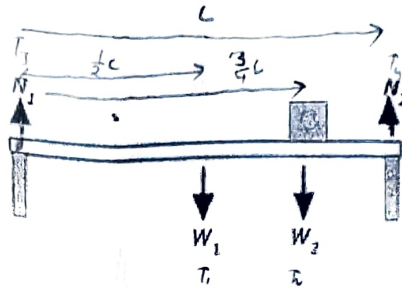
(c) State Archimedes Principle in words as well as in equation form. [2]

Q.4 (a) A child starts from the top of a slide of height 5 m. If he reaches the bottom with a speed of 8 m/s, what percentage of his energy at the top of the slide has been lost as result of friction? [10]

$$W_{fr} = \Delta KE$$



(b) A uniform bar of length  $L$  and  $W_1 = 35$  N is supported at its ends as shown below. A block of  $W_2 = 10$  N is placed at one quarter distance from the right hand side end. What are the magnitudes of the forces  $N_1$  and  $N_2$  exerted on the bar? [10]



$$mgl = E_{fr}$$

$$m \times 9.8 \times 5 = E_{fr}$$

$$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = -frd$$

Q.5 (a) Find the minimum amount of ice at  $-10^\circ\text{C}$  needed to bring the temperature of 100 g of water at  $20^\circ\text{C}$  down to  $0^\circ\text{C}$ . Given that  $c_{ice} = 2.09$  kJ/kg,  $H_{ice} = 335$  kJ/kg, and  $c_{water} = 4.185$  kJ/kg. $^\circ\text{C}$ . [9]

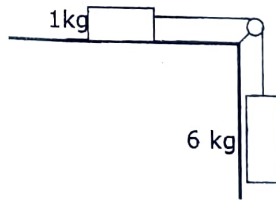
(b) An aluminium wire 3 mm diameter and 4 m long is used to support a mass of 50 kg. What is the elongation of the wire? Aluminium Young's modulus is  $7.07 \times 10^{10}$  Pa. [7]

always Hooke's law before breaking point

$$l = MC \Delta T$$

(c) Define the elastic limit of a material. [3]

Q.6 (a) The coefficient of kinetic friction between the table top and the 1 kg mass on top of it is 0.30. If the pulley is taken to be mass-less and frictionless, and the connecting rope mass-less, use energy methods to calculate the speed of the hanging 6 kg block after it has descended 0.8 m from its starting point at rest. [10]



$W_{fr} = \Delta KE$

$$ME_i = ME_f$$

$$PE_i + KE_i = PE_f + KE_f$$

$$PE_i = KE_f$$

$$mgh = \frac{1}{2}mv^2$$

$$gh = \frac{1}{2}v^2$$

$$10 \text{ m/s} \rightarrow 1 \text{ cm}$$

$$3 \rightarrow n$$

$$\frac{10n}{10} = \frac{3}{10}$$

$$n = 0.3 \text{ cm}$$

$$mgl$$

$$1 \times 9.8 \times 5$$

$$E_{fr} = W_{fr}$$

$$ma = W$$

$$(m_A + m_B) a = m_B g$$

$$(1 + 6) a = 6 \times 9.8$$

$$a = 8.4 \text{ m/s}^2$$

4

$$v^2 = u^2 + 2as$$

$$v^2 = 0 + 2(8.4)(0.8)$$

$$v^2 = 13.44$$

$$v = 3.66 \text{ m/s}$$

$$W_{fr} = \Delta KE$$

$$\frac{1}{2}mv^2 = \mu N d$$

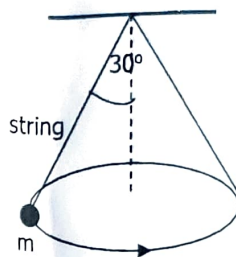
$$= \mu mgd$$

$$F_{fr} = \frac{1}{2}mv^2 - \mu mgd$$

6) A gun of mass 4 kg recoils with a speed of 0.5 m/s when it fires a bullet of mass 10 gram horizontally.

- i) Find the speed with which the bullet is fired,
- ii) If the bullet embeds itself in a 1.99 kg block of wood at rest on a horizontal table, with what velocity does the block move?
- iii) If the block (+bullet) stops after 10 cm, what is the coefficient of sliding friction between the block and the table? [10]

Q.8 (a) A small body of mass  $m$  revolves in a horizontal circle at a constant speed at the end of a string of length 1.2 m. As the body revolves the string describes the surface of a right circular cone. If the angle between the vertical and side of the cone is  $30^\circ$ , calculate the speed of the body both in m/s and rad/s, and the time the body takes to complete one revolution. [10]



(b) A balloon filled with helium gas has a volume of  $1500 \text{ m}^3$ . The density of helium is  $0.178 \text{ kg/m}^3$  and has a gross weight of 3500 N. Given that the density of air is  $1.293 \text{ kg/m}^3$ . What is the maximum load can this balloon lift? [8]

(c) Define the buoyant force. [2]

**END OF EXAMINATION**

$$D_B \leq D_A \quad 1500$$

$$\frac{m}{V} \leq 1.293 \quad \frac{m}{1500} \leq 1.293$$

$$3500N$$

## Equations

### Uniformly accelerated motion:

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

### Projectile motion:

$$v_x = v_i \cos \theta_i = \text{constant} \quad v_y = v_i \sin \theta_i - gt \quad y = (v_i \sin \theta_i)t - \frac{1}{2}gt^2$$
$$y = (\tan \theta_i)x - \left[ \frac{g}{2v_i^2 (\cos^2 \theta_i)} \right] x^2 \quad R = \frac{v_i^2}{g} \sin 2\theta \quad t = \frac{2v_i \sin \theta}{g}$$

### Force and motion:

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

### Energy:

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

### Linear momentum:

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

### Circular motion and gravitation:

$$T = \frac{2\pi r}{v} \quad a_c = \frac{v^2}{r} \quad F_c = \frac{mv^2}{r} \quad F_{grav} = G \frac{m_A m_B}{r^2}$$

### Rotational motion and angular momentum:

$$\theta = \frac{s}{r} = \left( \frac{\omega_i + \omega_f}{2} \right) t \quad \omega = \frac{\theta}{t} \quad \theta = \omega_i t + \frac{1}{2}\alpha t^2 \quad \omega_f = \omega_i + \alpha t$$
$$v = \omega r \quad \omega_f^2 = \omega_i^2 + 2\alpha\theta \quad \alpha = \frac{\Delta\omega}{\Delta t} = \frac{a_r}{r} \quad I = \sum mr^2$$
$$KE_{rot} = \frac{1}{2}I\omega^2 \quad \tau = FL = I\alpha \quad W = \tau\theta \quad P = \tau\omega \quad L = I\omega$$

### Properties of matter:

$$\rho = \frac{m}{V} \quad F = -kx \quad \phi = \frac{s}{d} = \frac{1}{s} \frac{F}{A} \quad Y = \frac{F/A}{\Delta L/L}$$