



The University of Zambia
Physics Department
Final Examinations 2021-22
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:

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

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

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

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

$$C_{\text{water}} = 4184 \text{ J/kg} \cdot ^\circ\text{C}$$

$$R = 8314 \text{ J/kmol} \cdot \text{K}$$

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

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$$

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

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

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

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

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

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

$$k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$$

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

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

Some Useful Equations

Uniformly accelerated motion:

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

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:

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

Rotational motion and angular momentum:

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

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

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

Properties of matter:

$$\rho = \frac{m}{V} \quad F = -kx \quad \frac{\Delta L}{L_i} = \frac{1}{Y} \frac{F}{A} \quad \phi = \frac{s}{d} = \frac{1}{s} \frac{F}{A} \quad B = -\frac{\Delta P}{\Delta V / V_0}$$

$$W_{app} = W \left(1 - \frac{\rho_{fluid}}{\rho} \right) \quad F_b = \rho V g, \text{ submerged object} \quad F_b = Mg \text{ floating } M$$

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) The only modulus that applies to liquids is
- Young's modulus
 - bulk modulus
 - shear modulus
 - modulus of rigidity
- (B) The acceleration of gravity on the planet Mars is 3.7 m/s^2 . Compared with her mass and weight on Earth, an astronaut on Mars has
- less mass and less weight
 - less mass and more weight
 - the same mass and less weight
 - less mass and the same weight
- (C) The pressure at the bottom of a vessel filled with a liquid does not depend on the
- acceleration due to gravity
 - area of the liquid surface
 - liquid density
 - height of the liquid
- (D) A modulus of elasticity is a ratio of
- stress to deformation
 - stress to strain
 - strain to stress
 - elongation to deformation
- (E) The product of the force and the perpendicular distance between some point and the line of application of the force is
- the moment of inertia acting on the object
 - the angular momentum of the object
 - torque
 - lever
- (F) In an elastic collision
- momentum is conserved and not kinetic energy
 - neither momentum nor kinetic energy is conserved
 - momentum and kinetic energy are both conserved
 - kinetic energy is conserved and not momentum
- (G) The moment of inertia of an object does not depend on:
- its mass
 - its size and shape
 - its angular speed
 - the location of the axis of rotation

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

- 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

- 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 the same for both
- 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 greater for the one shot off the cliff horizontally

Attempt any four questions from the following:

Q 2 (a) Given that vector **A** is 70 N in magnitude and directed at angle of 30° with respect to the positive x -axis and vector **B** is 50 N in magnitude at angle of 110° with respect to the positive x -axis, find

- i) the resultant vector **R**, its magnitude and direction, and [10]
- ii) sketch the resultant on an x - y plane. [2]

(b) A boy drops a stone from the edge of a bridge. After an interval of 2.5 seconds the stone hits the water. How high is the bridge from the water? [5]

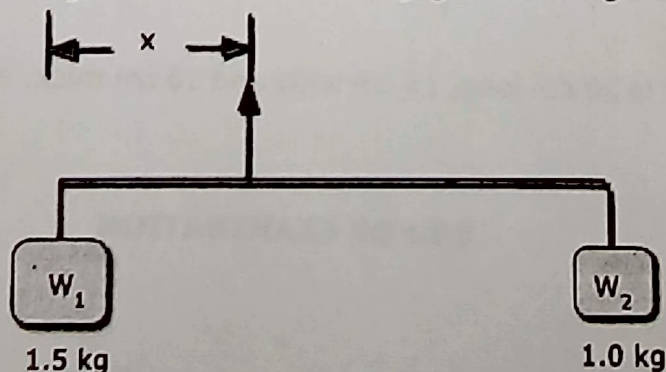
(c) A force of 20 N pulls a boat through 30 m of a canal. The angle between the force and the displacement is 25° . Calculate the work done. [3]

Q.3 (a) A ball of mass m moving at 5.00 m/s east strikes a stationary ball of the same mass. After the collision the first ball moves at 4.33 m/s at an angle of 30° with respect to the original direction (i.e. above the original line of motion). Find

- i) the velocity of the second ball, and
- ii) its direction [8]

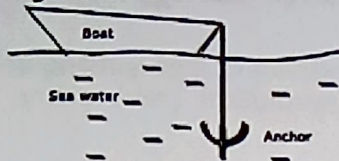
(b) A steel wire is 50 cm long and has a diameter of 0.5 mm. Young's modulus of steel is 20×10^{10} N/m². What force is required to increase the length of this wire by 1.0 mm? [6]

- (c) A uniform disk released from the top of an inclined plane reaches the bottom with a speed of 13 m/s. How high is the upper end of the inclined plane relative to the bottom? Assume that the disk rolls without slipping and that there is no friction loss. Given that $I_{\text{disk}} = \frac{1}{2}mr^2$. [6]
- Q.4 (a)** A ball is whirled (rotated) at the end of a string in a horizontal circle 50 cm in radius at the rate of 1 revolution (rev) every 2 seconds. Find the ball's centripetal acceleration. [5]
- (b) The speed limit along a certain road is 80 km/h. To stop at a junction, the driver applied excessive force on the brakes and skidded for 55 m before stopping. The coefficient of kinetic friction μ_k between the tyres and the road is 0.75. Determine if the driver exceeded the speed limit. [10]
- (c) A pontoon is 15 m long and 8 m wide. When two cars are driven on board, the pontoon sinks 5 cm into the water. What is the combined weight of the cars? Neglect the weight of the pontoon. [5]
- Q.5 (a)** A jet plane is flying in a horizontal direction with a velocity of 600 km/h and a height of 1960 m. When it is vertically above a point A, on the ground, a package drops from it. The package hits the ground at a point B. Calculate the distance AB. [10]
- (b) A solid wooden cube, 30 cm on each side, can be totally submerged in water if it is pushed downward with a force of 54.0 N. What is the density of the wood? [8]
- (c) State Archimedes Principle in words as well as in equation form. [2]
- Q.6 (a)** A young boy shoots a stone from a catapult at a speed of 15 m/s. The catapult is pointed 40° above the horizontal.
- i) How far (horizontally) from the catapult does the stone travel when it falls to the same level as the catapult? [9]
- ii) How long does the stone take to reach this level? [9]
- (b) A thin rod 1 m long has masses of 1.0 kg and 1.5 kg hanging at its ends. Find the point at which the rod can be lifted without the rod tending to rotate. Assume the weight of the rod to be negligible. See figure below. [9]



- (c) State the two conditions of equilibrium. [2]

- Q.7 (a)** How much force is needed to support a 100 kg iron anchor when it is immersed in sea water? The density of iron is $7.8 \times 10^3 \text{ kg/m}^3$ and that of sea water is $1.03 \times 10^3 \text{ kg/m}^3$. See figure below. [8]



- (b)** A car travelling at a speed of 54 km/h is brought to rest in 90 s. Find:

- i) retardation (deceleration), and
- ii) the distance travelled by the car before coming to rest. [8]

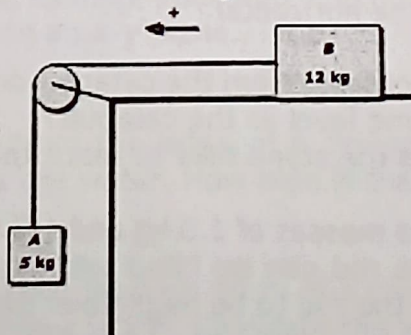
- (c)** i) How large must a horizontal force be exerted on an 8.5 g bullet to give it an acceleration of $18,500 \text{ m/s}^2$? [2]

- ii) With this acceleration, how fast will the bullet be going after it has moved 2.35 cm from rest? [2]

- Q.8 (a)** A road has a curve of radius 40 m and is banked at an angle θ such that friction is not necessary for a car to stay on the road. If a 2500 kg car is travelling at a speed of 25 m/s, find the angle θ . [7]

- (b)** The figure below shows a 5 kg block A which hangs from a string which passes over a frictionless pulley and is joined to a 12 kg block B which lies on a frictionless table.

- i) Find the acceleration of the two blocks.
- ii) Find the tension in the string [10]



- (c)** A block of wood is 20 cm long, 15 cm wide and 10 cm thick. What is the density of this block? [3]

END OF EXAMINATION