**STRATHMORE UNIVERSITY**
**SCHOOL OF COMPUTING AND ENGINEERING SCIENCES**
**Bachelor of Science in Electrical and Electronics Engineering**
**Final Examination**
**PHY 1101: PHYSICS 1**

**DATE: 16th November 2022** **TIME: 3 hours**

**Instruction:**

1. **This exam has FIVE questions.**
2. **Answer question 1 (Compulsory) and any two other questions.**

***Important constant***
Acceleration due to gravity = 9.8 m/s$^2$

## QUESTION 1 (20 MARKS)

a) You are using a triple beam balance shown in Fig. 1 to measure the mass of iron filings in milligrams. With reference to the beam balance, define zero and parallax errors and state ways in which they are corrected (4 marks)


*Figure 1: A triple beam balance*

b) A 0.3 kg object is moving in a plane with x and y coordinates given by $x = 5t^3 - 1$ and $y = 3t^3 - 2t^2 + 1$, where x and y are in m and t is in s. Find the magnitude and direction of the net force acting on the object at $t = 2.00\ s$ (5 marks)

c) Calculate the moment of inertia of a rigid uniform rigid rod of length L and mass M about an axis perpendicular to the rod and passing through its center of mass as shown in Fig. 3

(3 marks)

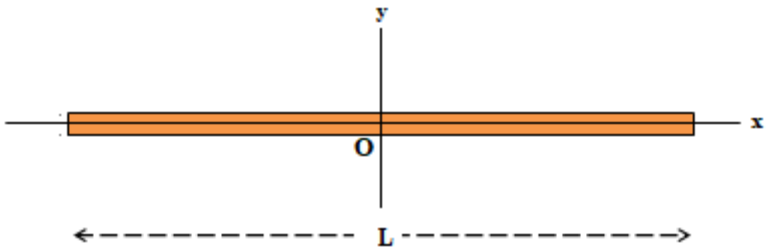


*Figure 3: A uniform rigid rod*

d) The information is stored digitally on surface of a compact disc, CD, in a series of pits, representing ones and flat areas, representing zeros, which can be read by a disc player and be converted back to sound waves. The pits and flats are detected by a system consisting of a laser and lenses. For the zeros and ones to be read by the same period, the tangential speed of the disc surface at the location of the lens must be constant. Therefore, the angular speed varies as the laser-lens system moves radially along the disc. The tangential speed of a typical CD at the point of the laser-lens system is 1.3 m/s.

Suppose the innermost track of the CD has a radius of 23 mm while the outmost final track has a radius of 58 mm as shown in Fig.2


*Fig. 2: A compact disk track*

(i) Find the angular speed, $\omega$, of the disc when the information is being read from the innermost and on the outmost tract (4 marks)

(ii) Given that the maximum playing time of a standard music CD is 74 min and 33 s, how many revolutions do the disk make during this time? (4 marks)

**QUESTION 2 (20 MARKS)**

a) An electron of mass $9.11 \times 10^{-31} kg$ has an initial speed of $3.00 \times 10^{3} ms^{-1}$. It travels in a straight line and its speed increases to $7.00 \times 10^{3} ms^{-1}$ in 5.00 m. Assuming that its acceleration is constant, determine the force exerted on the electron. (4 marks)

b) An object of mass 2.00 kg is attached to the hook of a spring balance and the later suspended vertically from the roof of a lift. Calculate the reading on the spring balance when the lift is

(i) Descending with an acceleration of 0.1 m/s$^2$ (2 marks)

(ii) Ascending with an acceleration of 0.2 m/s$^2$? (2 marks)

(iii)Moving with uniform velocity? (2 marks)

c) A machine carries a 4.0 kg package from an initial position of $d_i = (3.00\ m)\hat{\imath} - (2.00\ m)\hat{\jmath} + (5.00m)\hat{k}$ to a final position of $d_f = (-5.00\ m)\hat{\imath} + (4.00\ m)\hat{\jmath} + (7.00m)\hat{k}$ in 4.00 s by applying a constant force of $\vec{F} = (3.00\ N)\hat{\imath} + (7.00\ N)\hat{\jmath} + (7.00N)\hat{k}$. Find

(i) The work done on the object by the force in the 4.00 s interval (4 marks)

(ii) The angle between displacement and force (4 marks)

(iii)The average power due to the force during that interval (2 marks)

**QUESTION 3 (20 MARKS)**

a) A particle starts from the origin at $t = 0\ s$ with an initial velocity having the x component of $20\ m/s$ and a y component of $-15\ m/s$. The particle moves in the $xy$ plane with an x component of acceleration only, given by $a_x = 4.0\ m/s^2$

(i) Calculate the velocity of the particle at $t = 5\ s$ (4 marks)

(ii) Determine the position of the particle at any time t and the position of the particle at time $t = 5\ s$ (5 marks)

b) An elevator car has a mass of $1600\ kg$ and is carrying passengers having a combined mass of $200kg$. A constant friction force of $4000N$ retards its motion upward. Calculate the power that the elevators' motor needs to deliver to lift the elevator car at a constant speed of $3.00\ m/$s (3 marks)

c) A stone is thrown from the top of a building at an angle of 30.0$^o$ to the horizontal with an initial speed of 20.0 m/s. If the height of the building is 45.0 m. Find

(i) The time taken for the stone to reach the ground. (4 marks)

(ii) The speed of the stone just before it strikes the ground (4 marks)

## QUESTION 4 (20 MARKS)

1. A proton, A moving along the x-axis with a speed of $3.50 \times 10^5\ m/s^2$ collides with another proton, B, initially at rest. After the collision, proton A moves off at an angle of $37.0^o$ to the original direction of motion and the B is deflected at an angle of $\theta$ along the same axis as shown in Fig.4. Calculate the final speeds of the two protons and angle $\theta$. (13 marks)

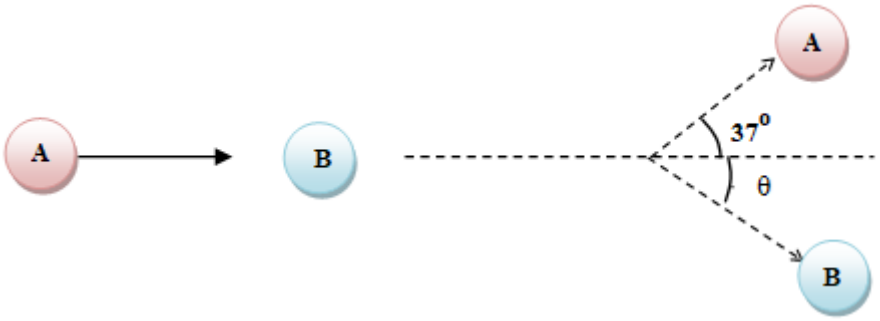


*Figure 4: Elastic collision of protons*

2. A 3.00 $kg$ crate slides down ramp is inclined at an angle of $30^o$ and 0.5 m high as shown in Fig.5. If the crate starts from rest at the top and it experiences a constant friction force of 5.00 $N$ and continues to move a short distance on the horizontal floor after it leaves the ramp, using energy methods, determine the speed of the crate at the bottom of the ramp. (7 marks)

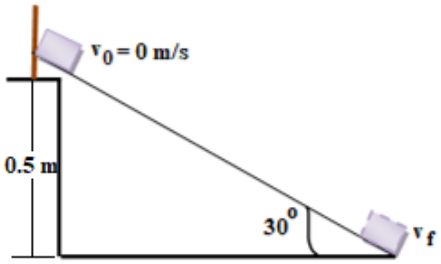


*Figure 5: Inclined ramp*

## QUESTION 5 (20 MARKS)

a) An object oscillates with simple harmonic motion along the x-axis. Its position varies with time according to the equation $x = (4.00)\cos\left(\pi t + \frac{\pi}{4}\right)$, where t is in seconds, the angles in the brackets are in radians, and x in metres.

(i) Determine the amplitude, frequency, and period of the motion (3 marks)

(ii) Calculate the acceleration of the object at any given time t (4 marks)

(iii) Using the results in (ii), determine the position, velocity, and acceleration of object at $t = 1.00\ s$. (3 marks)

b) A physical pendulum of length $0.500\ m$ (measured to 1 mm accuracy using a meter rule) takes $28.4\ s$ (measured to $0.1\ s$ accuracy using a stopwatch) to complete 20 oscillations. Given that $T = 2\pi\sqrt{\frac{l}{g}}$; where T is the periodic time, $l$ is the length of the pendulum, and $g$ is the gravitational acceleration, find the range of measured value of $g$. (4 marks)

c) A 200-g block connected to a light spring for which the force constant is 5.00 N/m is free to oscillate on a horizontal, frictionless surface. The block is displaced 5.00 cm from equilibrium and released from rest as shown in Fig. 6.

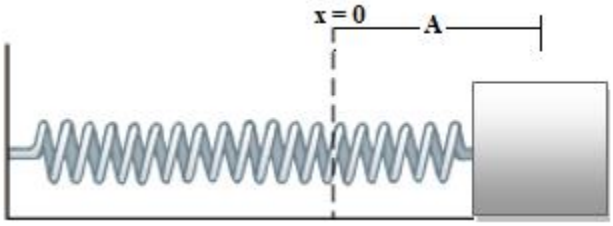


*Figure 3: 1 200-g block connected to a light spring*

(i) Find the period of its motion (4 marks)

(ii) Determine the maximum speed of the block (2 marks)