



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

**DATE: 1<sup>st</sup> October 2024**

**TIME: 13:00-15:30 Hours**

**Instruction:**

- 1. This exam has FIVE questions.**
- 2. Answer question 1 (Compulsory) and any two other questions.**
- 3. You may use a scientific calculator.**

***Important constants***

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

Atmospheric pressure,  $P = 1.013 \times 10^5 \text{ N/m}^2$

Density of copper  $\rho = 8.92 \times 10^3 \text{ kg/m}^3$

Average linear expansion coefficient of copper  $\alpha = 1.7 \times 10^{-5} (\text{°C})^{-1}$

Specific heat capacity of copper,  $c = 3.87 \times 10^2 \text{ J/kg°C}$

**QUESTION 1 (30 Marks)**

- a) State the two characteristics of conservative forces (2 marks)
- b) A small motor is used to operate a lift that raises load of bricks weighing  $500 \text{ N}$  to a height of  $10 \text{ m}$  in  $20\text{s}$  at a constant speed. The lift weighs  $300 \text{ N}$ . Find the power output of the motor. (2 marks)

c) The diameter of a uniform solid sphere is measured to be  $(12.00 \pm 0.20) \text{ cm}$  and its mass is measured to be  $(1.85 \pm 0.02) \text{ kg}$ . Determine the range of the density of the sphere in  $\text{kg/m}^3$ . (5 marks)

d) An electron in a cathode-ray tube of an initial  $1.50 \times 10^5 \text{ m/s}$  enters a region of length  $L = 1.00 \text{ cm}$  where it is electrically accelerated as shown in figure 1. It emerges with a velocity of  $5.70 \times 10^6 \text{ m/s}$ . Calculate the electrons' acceleration, which is assumed to be constant (3 marks)

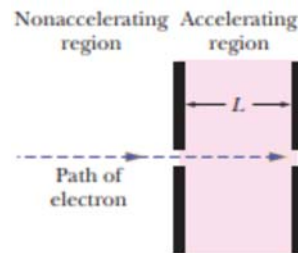


Figure 1

e) A block whose mass is  $680 \text{ g}$  is fastened to a spring whose spring constant  $k$  is  $65 \text{ N/m}$ . The block is pulled a distance  $x = 11 \text{ cm}$  from its equilibrium position at  $x = 0$  on a frictionless surface and released from rest at  $t = 0$ .

(i) Calculate the period of the resulting motion (3 marks)

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

(iii) Determine the magnitude of the maximum acceleration of the block (2 marks)

f) A picture weighing  $80 \text{ N}$  is supported by two wires with tensions  $T_1$  and  $T_2$  as shown in Figure 2.

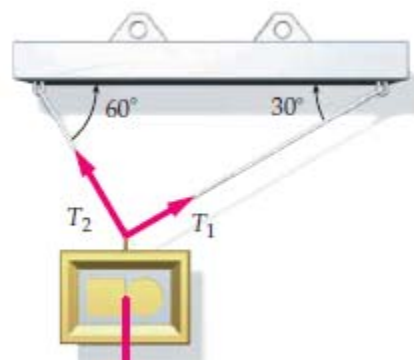


Figure 2

- (i) Draw a well labelled free-body diagram representing the forces acting on the picture (2 mark)
- (ii) Using Newtons' law of motions and other mathematical derivation, calculate the value of the tension forces,  $T_1$  and  $T_2$  (5 marks)
- g) A system consists of three particles of mass  $m_1 = m_2 = 1.0 \text{ kg}$  and  $m_3 = 2.0 \text{ kg}$  located in the planar coordinate system shown in Figure 3. Find the center of mass of the system. (3 marks)

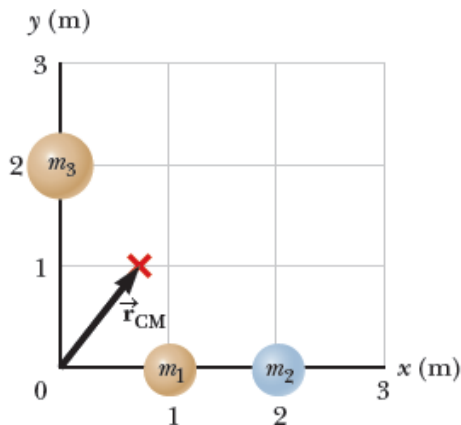


Figure 3

### QUESTION 2 (15 Marks)

- a) A pendulum swinging with simple harmonic oscillations moves fastest when it is at its lowest point. Explain the observation using the principle of conservation of mechanical energy (2 marks)
- b) The launching mechanism of a popgun consists of a trigger-released spring as shown in figure 4. The spring is compressed to position A,  $-0.12 \text{ cm}$  from the equilibrium point, as shown in the figure 4(a). A projectile of  $35.0 \text{ g}$  then rises to position C,  $0.20 \text{ m}$  above B, the equilibrium position as it leaves the spring as shown in figure 4 (b).

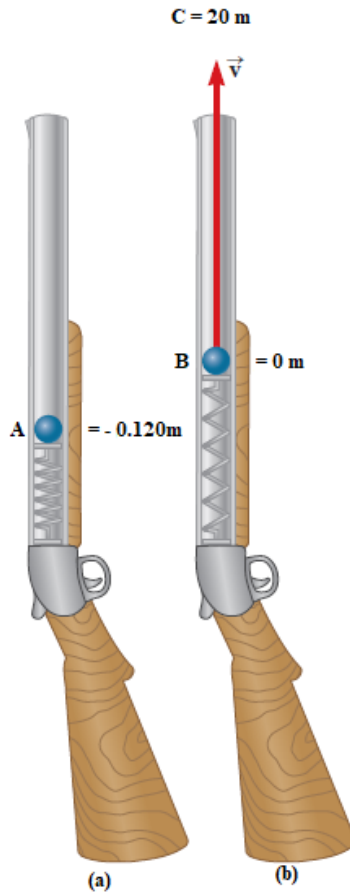


Figure 4

- (i) Neglecting all resistive forces, determine the spring constant (4 marks)
- (ii) Find the speed of the projectile as it moves through the equilibrium position shown in figure (b) (4 marks)
- c) A  $3.00 \text{ kg}$  crate slides down ramp is inclined at an angle of  $30^\circ$  and  $0.5 \text{ m}$  high as shown in Figure 5. If the crate starts from rest at the top and it experiences a constant friction force of  $5.00 \text{ N}$  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. (5 marks)

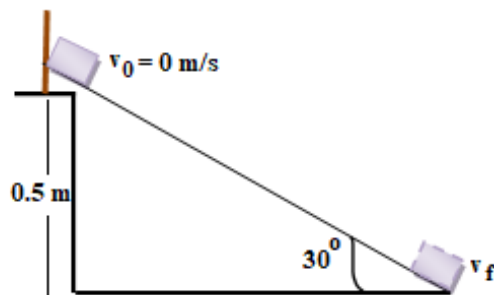


Figure 5

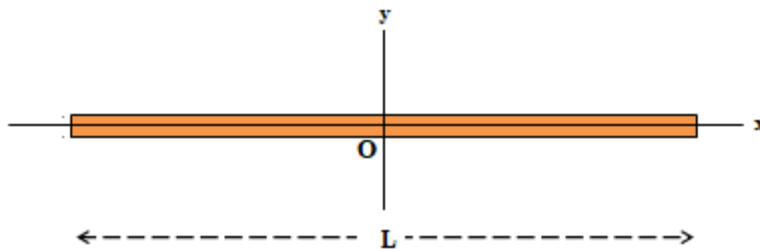
**QUESTION 3 (15 Marks)**

- a) You are using a triple beam balance shown in Figure 6 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 6: A triple beam balance*

- b) A machine carries a 4.0 kg package from an initial position of  $d_i = (3.00\text{ m})\hat{i} - (2.00\text{ m})\hat{j} + (5.00\text{ m})\hat{k}$  to a final position of  $d_f = (-5.00\text{ m})\hat{i} + (4.00\text{ m})\hat{j} + (7.00\text{ m})\hat{k}$  in 4.00 s by applying a constant force of  $\vec{F} = (3.00\text{ N})\hat{i} + (7.00\text{ N})\hat{j} + (7.00\text{ N})\hat{k}$ . 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 (3 marks)
  - (iii) The average power due to the force during that interval (1 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 figure 7. (3 marks)



*Figure 7*

#### QUESTION 4 (15 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 meters.
- (i) Determine the frequency, and period of the motion (2 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) The information is stored digitally on the 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 Figure 8



Figure 8

- (i) Find the angular speed,  $\omega$ , of the disc when the information is read from the innermost and on the outmost tract (3 marks)

- (ii) Given that the maximum playing time of a standard music CD is 74 min and 33 s, how many revolutions does the disk make during this time? (3 marks)

**QUESTION 5 (15 Marks)**

- a) Define the term the following thermodynamic process and state how each process is achieved (4 marks)
- (i) Adiabatic process
  - (ii) Isobaric
- b) A 1.0 kg copper bar is heated at atmospheric pressure. If its temperature increases from  $20^{\circ}\text{C}$  to  $50^{\circ}\text{C}$ , calculate,
- (i) The work done on the copper bar by the surrounding atmosphere (6 marks)
  - (ii) The quantity of energy transferred to the copper bar by heat (3 marks)
  - (iii) The increase in the internal energy of the copper bar (2 marks)