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

DATE: 1st November 2021 **TIME: 2 hours**

Instruction:

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

Important constants

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

Average linear expansion coefficient of steel, $\alpha = 1.1 \times 10^{-5} (^oC)^{-1}$

Average linear expansion coefficient of brass, $\alpha = 1.9 \times 10^{-5} (^oC)^{-1}$

Average linear expansion coefficient of aluminum, $\alpha = 2.4 \times 10^{-5} (^oC)^{-1}$

Latent heat of vaporization of steam (at 100^0C) $= 2.26 X10^6$ J/kg

Specific heat capacity of water = 4.19×10^3 J/ kg^{o}C

Specific heat capacity of copper = 3.87×10^2 J/ kg^{o}C

Specific heat capacity of aluminum = 9.00×10^2 J/ kg^{o}C

Latent heat of fusion of ethyl alcohol = 1.09×10^2 J/kg

Latent heat of vaporization of ethyl alcohol = 8.79×10^5 J/kg

Specific heat of ethyl alcohol = 2.43×10^3 J/kg.K

Acceleration due to gravity = 9.8 m/s^2

Universal gas constant = 8.314J/K.mol

Density of copper = 8.92×10^3 kg/m^3

Density of mercury = 1.36×10^4 kg/m^3

QUESTION1 (20 MARKS)

a) Using the first law of thermodynamics, explain why the total energy of an isolated system is always constant. (2 marks)

b) Ethyl alcohol has a boiling point of 78.0°C, a freezing point of -114°C. How much energy must be removed from 0.510 kg of ethyl alcohol that is initially a gas at 78.0°C so that it becomes a solid at -114°C? (4 marks)

c) An electron in an X-ray tube of an initial velocity $v_0 = 1.50 \times 10^5 m/s$ enters a region of length $L = 1.00\ cm$ where it is electrically accelerated as shown in Fig.1. It emerges with a velocity of $v = 5.70 \times 10^6 m/s$. Calculate its acceleration, which is assumed to be constant. (3 marks)

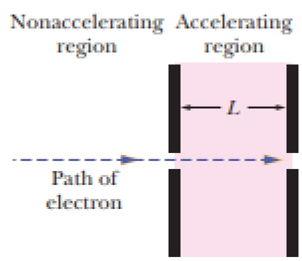


Fig. 1

d) Two forces, $\vec{F}_1 = 6.00\ N$ and $\vec{F}_2 = 7.00 N$ acts on a block of mass 0.2 kg placed at the origin O as shown in Fig.2 Calculate the acceleration of the block of mass in unit vector given that θ_1= 30°, and θ_2=40° (5 marks)

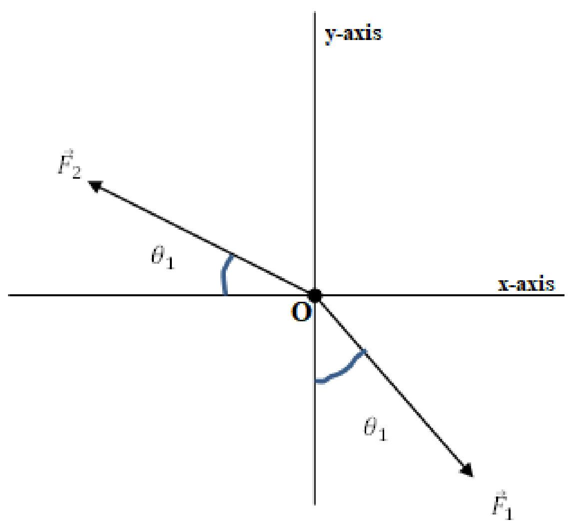


Fig. 2

e) A pendulum swinging with simple harmonic oscillations moves fastest when it is at its lowest point. Explain this observation. (2 marks)

f) Force $\vec{F} = (3x^2 N)\hat{\imath} + (4N)\hat{\jmath}$, with x in meters, acts on a particle, changing only the kinetic energy of the particle. How much work is done on the particle as it moves from coordinates (2m, 3m) to (3m, 0m)? (4 marks)

QUESTION 2 (20 MARKS)

a) Write a mathematical expression describing each of the following types of forces using Newton's second law of motion (4 marks)

(i) Gravitation force

(ii) Normal force

(iii) Weight

(iv) Frictional

b) State the properties of conservative forces (2marks)

c) A ball of mass *m* is dropped vertically downwards from a height *h* above the ground with an initial velocity of 0 m/s, as shown in Fig 3. Neglecting air resistance, determine the velocity of the ball when it is at a height *y* above the ground (4 marks)

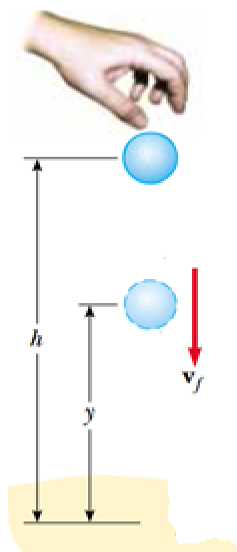


Fig. 3

d) A copper ring with mass of 25.0 g has a diameter of 5.00 cm at a temperature of 15.0°C. A spherical aluminum shell with mass 10.9 g has a diameter of 5.01 cm at a temperature higher than 15.0°C. The sphere is placed on top of the horizontal ring, and the two are allowed to come to thermal equilibrium without any exchange of energy with the surroundings. As soon as the sphere and ring reach thermal equilibrium, the sphere barely falls through the ring. Find

(i) The equilibrium temperature (4 marks)

(ii) The initial temperature of the sphere (2 marks)

e) In a particular crash test, a car of mass 1500 kg collides with a wall. The initial and final velocities of the car are $v_i = -15.0\ \hat{\imath}\ m/s$ and $v_f = 2.60\ \hat{\imath}\ m/s$ respectively. If the collision last 0.15 s, find the impulse caused by the collision and the average force exerted. (4 marks)

QUESTION 3 (20 MARKS)

a) Using appropriate equations, define the following thermodynamic process and explain how each of the processes is achieved

(i) Adiabatic (3 marks)

(ii) Isobaric (3 marks)

b) A copper bar of mass 1.0 kg is heated at atmospheric pressure. If its temperature increases from 20^o C to 50^o C, calculate

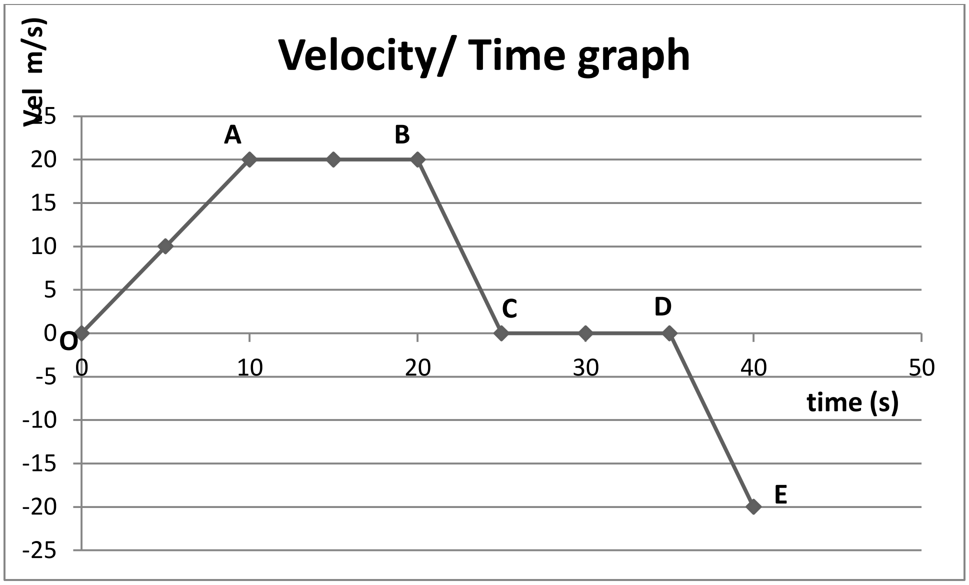
(i) The work done on the copper bar by the surrounding atmosphere (8 marks)

(ii) The quantity of energy that is transferred to the copper bar by heat (3 marks)

(iii) The increase in the internal energy of the copper bar (3 marks)

QUESTION 4 (20 MARKS)

a) A particles' velocity (in m/s) plotted against time (in seconds) as shown in graph 1.0



Graph 1.0

(i) Describe the motion of the particle (3 marks)

(ii) Calculate the total distance covered by the object (3 marks)

b) 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) Determine the components of the velocity vector at any time and the total velocity in unit vector notation at any time (3 marks)

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

(iii) Determine the position of the particle at any time t and the position of the particle at time $t = 5\ s$ (6 marks)

QUESTION 5 (20 MARKS)

a) Given that $\vec{A} = 3.0\hat{\imath} + 5.0\hat{\jmath}$ and $\vec{B} = 2.0\hat{\imath} + 4.0\hat{\jmath}$, evaluate $\vec{A}.\vec{B}$, and the angle between the vectors $\vec{A}$ and $\vec{B}$ (5 marks)

b) A block of mass $m_1 = 1.60\ kg$ initially moving to the right with a speed of 4.00 m/s on a frictionless horizontal track collides with a spring attached to a second block of mass $m_2 = 2.10\ kg$ initially moving to the left with a speed of 2.50 m/s, as shown in Fig. 4

(a). Given that there is conservation of both momentum and kinetic energy and the spring constant is 600 N/m

i. Calculate the velocities of the two blocks after collisions (5 marks)

ii. During the collision, at the instant block 1 is moving to the right with a velocity of $+3.00\ m/s$, as shown in Fig. 4(b), determine the velocity of block 2 (3 marks)

iii. Determine the distance the spring is compressed at the instant in (ii) (3 marks)

iv. The maximum compression of the spring during this collision (4 marks)

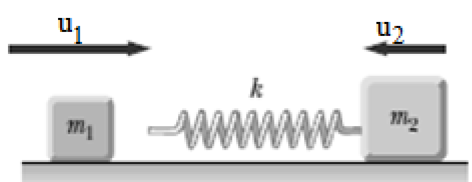


Fig. 4(a)

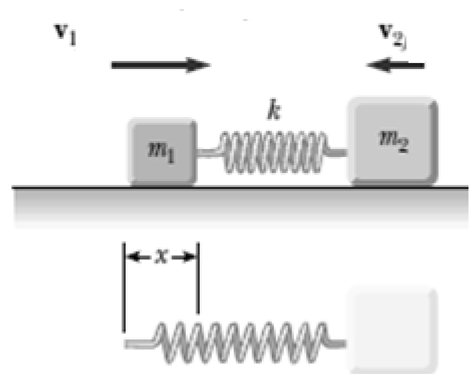


Fig. 4(b)