SIR ARTHUR LEWIS COMMUNITY COLLEGE
ACADEMIC YEAR (2024/2025) – SEMESTER ONE
END OF SEMESTER EXAMINATION

COURSE TITLE	**:**	**MECHANICS II, HEAT AND THERMODYNAMICS**
COURST CODE	**:**	**PHY217**
LECTURER	**:**	**ALEXANDER DANIEL**
DATE	**:**	**Wednesday 18th December 2024**
TIME	**:**	**9.00 – 11.00 AM**
DURATION	**:**	**2 HRS**
STUDENT ID#	**:**	**……..**

GENERAL INFORMATION AND INSTRUCTIONS

1. Write your student's ID number on all the work you hand in.
2. This paper consist of eight (8) structured questions.
3. **Choose any five (5) questions** and write solutions on the answer sheet/s.
4. Formulae used in obtaining solutions must first be stated.
5. Students must produce sufficient working steps, to justify solution.
6. Use appropriate units with answers.
7. Number all questions attempted properly.
8. All submitted work must be in ink/pen (preferably Blue or Black).
9. Write legible.
10. Do not use correction fluid.

ADDITIONAL INFORMATION

Data sheets are provided for the exam.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

QUESTIONS

1. (a) The components of a vector **V** can be written as (V_x, V_y, V_z) What are the components of the resultant of the two vectors, $\boldsymbol{V_1}$ and $\boldsymbol{V_2}$ whose components are $(4.0, -3.7, 2.0)$ and $(5.0, 0.0, -7.2)$.

   (i) What are the components of the resultant vector? [3]

   (ii) What is the magnitude of the resultant vector? [3]

   (b) Two horizontal forces F_1 = 200 N act at 20° West of North and F_2 = 150 N act at 15° East of North.

   (i) Find the angle between the two forces. [2]

   (ii) Find the cross (vector) product of the forces, $F_1 \times F_2$ [4]

2. (a) The speed of a boat in still water is represented by the notation as v_{BW}. The boat can travel at 3.2 $m\ s^{-1}$ in still water. The boat's prow points directly across a river whose water current is 1.2 $m\ s^{-1}$.

   (i) Use the notation above to represent the velocity of the boat relative to the shore. [2]

   (ii) What is the velocity of the boat, relative to the shore? [6]

   (b) A car and a truck, 250 m approach each other on a straight highway with speeds of 14 $m\ s^{-1}$ and 20 $m\ s^{-1}$ respectively.

   How long would it take for the vehicles to meet? [4]

3. (a) A batsman strikes a cricket ball with at a height of 0.30 m, at an initial speed of 35 $m\ s^{-1}$ at a 25 °angle to the horizontal. The ball is caught by a fieldsman at a height of 2.2 m above the ground.

   (i) What was the initial vertical speed of the ball when it was struck? [2]

   (ii) How long did it take for the ball to be caught? [6]

   (iii) How far was the catcher from the batsman when the ball was caught? [2]

   (b) State any assumptions made in your calculations above. [2]

4. The angle through which a rotating wheel has turned in time t is given by

$$\Theta = 6.8\ t - 5.0\ t^2 + 3.2\ t^4$$

   where Θ is in radians and t in seconds.

   (a) What is the angular displacement after 2.0 s? [2]

   (b) What is the average angular velocity for the first 2.0 s? [2]

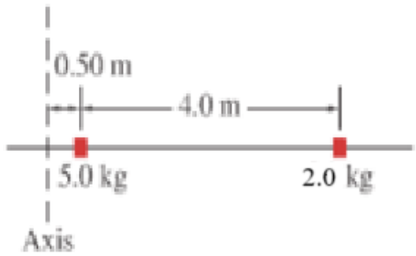
   (c) Derive an equation for instantaneous angular velocity ω. [3]

   (d) What is the angular velocity at time t = 2.0 s ? [2]

   (e) What is the angular acceleration ω at time t = 3.0 s? [3]

5. (a) Explain what is meant by moment of inertia **I** and discuss the factors that affect the moment of inertia of a body. [3]

(b) Two small weights of mass 5.0 kg 7.0 kg are mounted 4.0 m apart on a light rod as shown below.

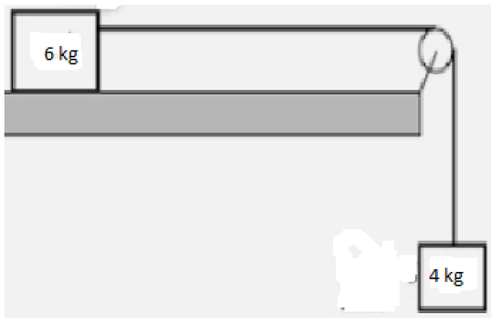


Calculate the moment of inertia I of the system when it is rotated about an axis 0.50 m to the left of the 5.0 kg mass. [4]

(c) The system in (b) above, rotates at 4 revolutions per second. Calculate:

(i) its angular momentum L, [3]
(ii) its rotational kinetic energy. [2]

6. (a) A 6.0 kg mass is placed on a horizontal table and attached to a 4.0 kg mass via a string over a pulley. The 4 kg mass is allowed to hang freely as shown below.



The coefficient of dynamic friction between the table and the 6 kg mass is 0.20. Calculate:

(i) the frictional force acting on the 6.0 kg mass. [1]
(ii) the acceleration of the system. [4]

(b) (i) Explain what is meant by a geostationary satellite and why it must be located over the equator. [3]

(ii) What is the gravitational force acting on an object of mass 5000 kg, at a height of 4000 km above the Earth's surface? [4]

7. (a) An ideal gas in a sealed container, initially at a temperature of 27°C and 100 kPa pressure, is heated at constant volume until its temperature is 100 °C. The container valve is then opened to allow gas to escape until the pressure falls back to 100 kPa at 100 °C. Calculate:

(i) the pressure at 100°C before the valve was opened. [3]
(ii) the fraction of the initial mass of gas lost as a result of opening the valve. [3]

(b) In an experiment, 24 cm^3 of a certain gas is collected at a temperature of 17 °C and a pressure of 105 kPa.

(i) Calculate the volume that the gas would occupy at standard pressure (101 kPa) and 0 °C. [3]

(ii) Given that one mole of an ideal gas at standard pressure and 0°C occupies a volume of 0.0224 m^3. Calculate the number of gas molecules collected in the experiment. [3]

8. (a) Explain why the temperature of a gas increases when it is adiabatically compressed. [3]

(b) An ideal gas is compressed at a constant total pressure of 4.0×10^5 Pa from 800 cm^3 to 500 cm^3. Heat then flows out of the gas at constant volume, and the pressure and temperature are allowed to drop until the temperature reaches its original value. Calculate,

(i) the total work done by the gas in the process, and [3]
(ii) the total heat flow out of the gas. [2]

(c) Four kilogram of water is heated from 20 °C to 80 °C. Estimate the change in entropy of the water. [4]

END OF EXAMINATION