00329

The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc / B. Ed Degree Programme

Department	: Physics
Level	: 03
Name of the Examination	: Final Examination
Course Code and Title	: **PHU3300 - General and Thermal Physics**
Academic Year	: 2020/2021
Date	: 2021-12-20
Time	: 9.30 am – 11.30 am
Duration	: 02 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 06 questions in 06 pages.
3. Answer any **04** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Draw fully labelled diagrams where necessary
5. Relevant log tables are provided where necessary.
6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense.
7. Use blue or black ink to answer the questions.
8. Circle the number of the questions you answered in the front cover of your answer script.
9. Clearly state your index number in your answer script

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Department of Physics
The Open University of Sri Lanka
Bachelor of Science Degree Programme
Level 3
PHU3300- General and Thermal Physics

FINAL EXAMINATION

Duration - two hours (2 hrs.) **ANSWER FOUR QUESTIONS ONLY**

Date: 20.12.2021 **Time: 9.30am-11.30am**

1. (a) (i) State and prove the principle of conservation of linear momentum. **(4 marks)**

(ii) Show that a gun recoils when a bullet is fired from it. **(2 marks)**

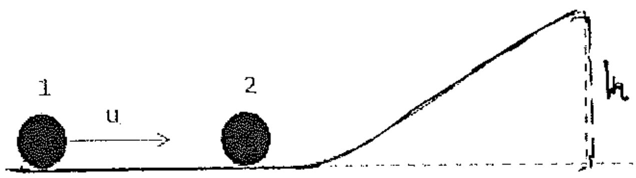
(iii) In the context of a collision between two bodies, explain what is meant by the terms elastic, inelastic and totally inelastic collisions. **(6 marks)**

(b) Two billiard balls sit on a horizontal surface next to a smooth inclined plane of height h as shown in the figure below. Ball 1 with mass m_1 approaches Ball 2 (initially stationary) with an initial velocity u in the positive x direction. It then makes an elastic collision with Ball 2 (mass m_2).

(i) What is the speed of Ball 1 immediately after the collision and in which direction is it moving? **(3 marks)**

(ii) What is the kinetic energy of Ball 2 immediately after the collision? **(2 marks)**

(iii) What is the maximum height that Ball 2 reaches up the inclined plane after the collision, assuming it does not get to the top? **(2 marks)**



(c) (i) If the collision had been totally inelastic, what initial velocity would be required for both balls to reach the top of the inclined plane after the collision? **(3 marks)**

(ii) Determine the required velocity of Ball 1 before the collision. **(3 marks)**

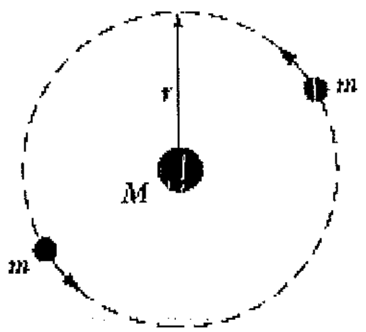
2. (a) State Kepler's three laws of planetary motion. **(3 marks)**

(b) Show that an artificial satellite circling around the Earth in an orbit of radius obeys Keller's Third Law. **(4 marks)**

(c) State the two essential requisites for the satellite to behave as a geostationary satellite. **(2 marks)**

(d) Derive an expression for the radius of a geostationary satellite. **(2 marks)**

(e) A certain triple-star system consists of two stars, each of mass m, revolving in the same circular orbit of radius r around a central star of mass M as shown in the figure. The two orbiting stars are always at opposite ends of a diameter of the orbit.



(i) Show that the net gravitational force F acting on one of the revolving stars as

$$F = \frac{Gm}{4r^2}\left(4M + m\right)$$ **(4 marks)**

(ii) Show that the speed v of the revolving star as

$$v = \sqrt{\frac{G\left(4M + m\right)}{4r}}$$ **(4 marks)**

(iii) Show that the period of revolution T of the revolving stars as

$$T = \frac{4\pi r^{3/2}}{\sqrt{G\left(4M + m\right)}}$$ **(4 marks)**

(iv) When $m \ll M$ show that the triple-star system satisfies the Kepler's third law. **(2 marks)**

3. Explain the property of surface tension of a liquid and the factors that effect on it. **(5 marks)**

A capillary tube of radius r is completely dipped into a container of water, then raised up vertically such that one end of the tube is still in the water. A column of water of height h is pulled up the tube by capillary action. In a capillary tube, such as the one used in this experiment, the surface of the water may be considered to be hemispherical.

(a) As a first approximation, assume that $h >> r$ and so show that the surface tension T acting around the circumference of the circle of contact of the water in the tube is given by

$$T = \frac{g\rho hr}{2}$$

where ρ is the density of water and g is the acceleration due to gravity

(2 marks)

(b) Show that a more accurate expression for T is

$$T = \frac{1}{2} g\rho r\left(h + \frac{r}{3}\right)$$

(3 marks)

(c) Two students in the Level 3 laboratory measure the diameter of the capillary tube across five different axes with a travelling microscope, and find it to be an average of 1.89 $\pm$0.03 mm. The height of the column of water in the capillary tube is measured with a ruler and found to be 1.45 ± 0.05 cm high. Calculate the value of T and its uncertainty. **(10 marks)**

(d) In this experiment, would a significantly different value of T have been obtained using the formula from part (a). How should the students improve their experiment to get a more accurate result? **(5 marks)**

4. Explain significance of the continuity equation of fluid flow and write down the two real life practical examples of equation of continuity. **(5 Marks)**

(a) A pipe consists of two joined segments, the first with diameter 20.0 mm, and the second with diameter 10.0 mm. Water flows out of the second segment with a velocity of 0.100 m s^{-1}. What is the volume of water per second fed into the first segment of the pipe, and what velocity does it have in that segment? **(4 marks)**

(b) What is Bernoulli's Principle and write down the equation related to it. Explain about the limitation of Bernoulli's equation. **(6 marks)**

(c) The flow from the pipe described in section (a) feeds into a cylindrical bucket, open at the top, which is 25.0 cm high and 10.0 cm in diameter. Tragically, there is a hole in the bottom of the bucket with diameter 2.50 mm. Calculate the equilibrium height of the water in the bucket. **(6 marks)**

(d) How would the equilibrium height of the fluid in the bucket change if the water in the pipe was replaced with mercury with density 1.35×10^4 kg m^{-3}? **(4 marks)**

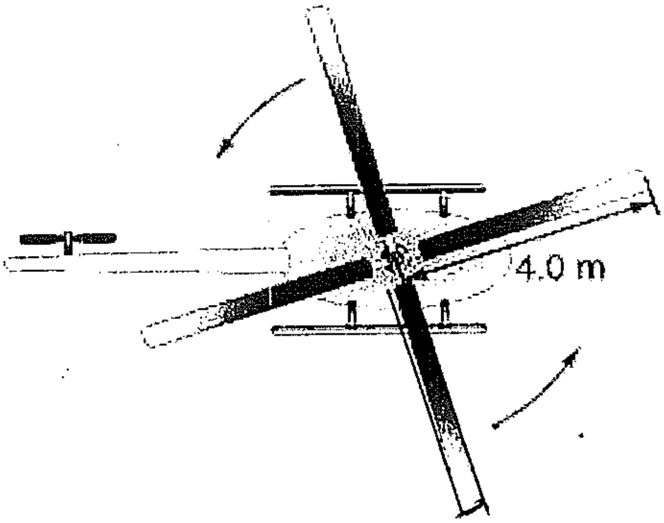
5. What is meant by the moment of Inertia of a rotating system? **(2 marks)**

(a) (i) What is the moment of inertia of a propeller (See Figure)with four blades (treated as rods) of mass m, length L, at 90° relative to each other ? **(3 marks)**

(ii) If a torque τ acts on this how long will it take to reach an angular velocity ω? **(3 marks)**

(iii) How many revolutions will it make before reaching this ω? **(2 marks)**

(b) As shown in the figure, a small helicopter, has four blades. Each is 4.00 m long and has a mass of 50 kg. The blades can be approximated as thin rods that rotate about one end of an axis perpendicular to their length. The helicopter has a total loaded mass of 1000 kg.



(i) Calculate the rotational kinetic energy in the blades when they rotate at 300 rpm . **(5 marks)**

(ii) Calculate the translational kinetic energy of the helicopter when it flies at 20.0 m/s, and compare it with the rotational energy in the blades. **(5 marks)**

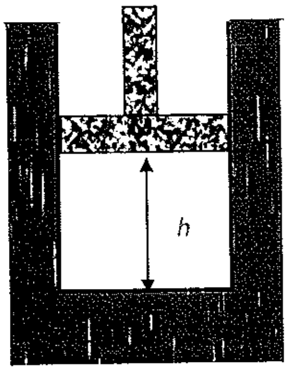
(iii) To what height could the helicopter be raised if all of the rotational kinetic energy could be used to lift it? **(5 marks)**

6. (a) (i) What is an ideal gas ? **(2 marks)**

(ii) State the ideal gas law and prove the ideal gas equation using the two gas laws **(3 marks)**

(b) A cylinder whose inside diameter is 4.00 cm contains air compressed by a piston of mass m = 13.0 kg, which can slide freely in the cylinder. The entire arrangement is immersed in a water bath whose temperature can be controlled. The system is initially in equilibrium at temperature of 20 ^{0}C. The initial height of the piston above the bottom of the cylinder is h_i = 4.00 cm. The temperature of the water bath is gradually increased to a final temperature of 100 ^{0}C. Calculate the new height of the piston above the bottom of the cylinder (h_f)

(10 marks)



(c) Starting from the same initial conditions, the temperature is again gradually raised, and weights are added to the piston to keep its height fixed at h_i. Calculate the total weight that has been added when the temperature has reached $t_f = 100$ °C . **(10 marks)**

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