00386

THE OPEN UNIVERSITY OF SRI LANKA
DEPARTMENT OF PHYSICS
BACHELOR OF SCIENCE DEGREE PROGRAMME -2019/2020 - LEVEL 03
PYU1160/PHU3300 – GENERAL AND THERMAL PHYSICS
FINAL EXAMINATION

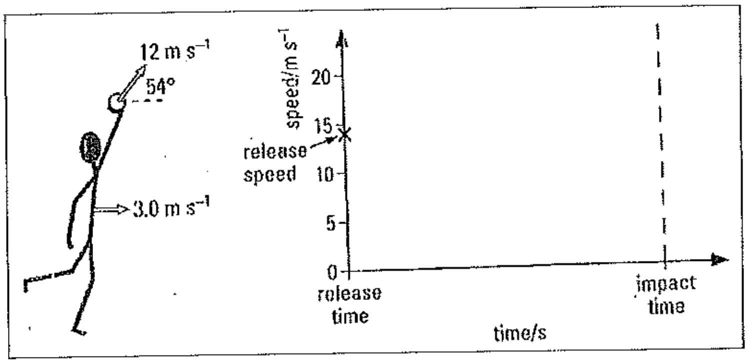
TIME: TWO HOURS (2 hrs) **ANSWER FOUR QUESTIONS ONLY**

Date: 08.01.2020 Time: 9.30 am – 11.30 am

1. (a)(i) Briefly explain what you meant by the terms "Work", "Energy" and "Power"

(ii)Write down conditions, under which the work done by a force is "zero", "positive" and "negative".

(iii) State clearly the "Work- Energy" principle. **(10)**



(iv) The shot-putter shown in figure throws the shot forwards with a velocity of 12 ms^{-1} with respect to his hand, in a direction 54° to the horizontal. At the same time, the shot-putter's body is moving forward horizontally, with a velocity of 3.0 ms^{-1}.

(b) Draw a vector diagram to show the addition of the two velocities of the shot at the moment of release. Hence, or otherwise, show that the vector sum of the two velocities has a magnitude of approximately 14 m s^{-1}. **(5)**

(c) At the moment of release, the shot is 2.3 m above the ground. The shot has a mass of 7.3 kg.

(i) Calculate the kinetic energy of the shot at the moment of release.

(ii)Calculate the potential energy, relative to the ground, of the shot at the moment of release. The acceleration of free fall, g is 9.8 ms^{-2}

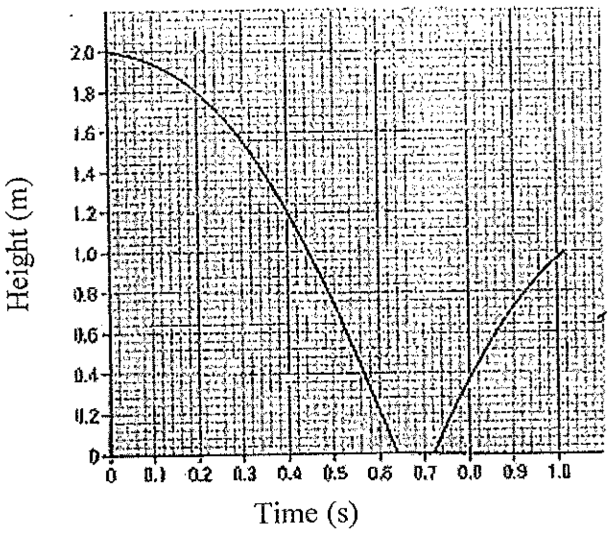
(iii) Use the law of conservation of energy to calculate the speed of the shot as hits the ground. (Neglect air resistance)

(iv) Copy the figure above and sketch the variation of the shot's speed with time, up to the moment when it touches the ground. **(10)**

2. Explain conservation of momentum and two related practical applications.
A snooker ball A of mass 0.2 kg travelling at 2.5 ms^{-1} collides elastically and head-on with a second, identical, stationary ball *B*. They remain in physical contact for 50 μs.

(i) What does perfectly elastically mean?

(ii) Find the speed and direction of motion of *A* and of *B* after the collision. **(10)**



(b) A rubber ball of mass 0.120 kg is dropped from a height of 2.00 m (measured from the bottom of the ball) on to a flat horizontal patch of hard soil.

(i) Calculate the speed of the ball when it hits the ground.
The rubber ball loses speed each time it bounces. Figure shows how the height of the bottom of the ball varies with time during the first second of its motion.

(ii) Use the graph to show that the speed of the ball as it leaves the ground is approximately 4.7 m s^{-1}.

(iii) Calculate the average force exerted by the ground on the ball while it is in contact with the ground. **(15)**

3. Rockets are propelled by the ejection of the products of the combustion of fuel. Consider a rocket of total mass (rocket plus fuel) m_1 to be travelling at speed v_1 in a region of space where gravitational forces are negligible. Suppose that the combustion products are ejected at a constant speed (exhaust speed) v_r relative to the rocket. Show that a fuel 'burn' which reduces the total mass of the rocket to m_2 results in an increase in the speed of the rocket to v_2 such that

$$v_2 - v_1 = v_r \ln \frac{m_1}{m_2}$$ **(10)**

A rocket for use in deep space is capable of increasing the speed of the total load (rocket plus fuel) of 3.00 x 10^3 kg to 1.0 x 10^4 m s^{-1}.

(a) If the rocket has an engine and fuel designed to produce an exhaust speed of 2.0 x 10^3 m s^{-1}, how much fuel is required to reach the speed 1.0 x 10^4 m s^{-1}?

(b) If the fuel consumption rate of the rocket is 884 kg/s and produces the exhaust speed of 2.0 x 10^3 ms^{-1}, what is the rockets' thrust?

(c) How long the rocket engine is being fired to reach the speed 1.0 x 10^4 m s^{-1}?

(d) If a different fuel and engine design could give an exhaust speed of 2.5 times higher than that in part (a), what amount of fuel would be required for the same task?

(15)

4. State Kepller's three laws of planetary motion. **(6)**

(a) For a point at the surface of the earth, the acceleration due to gravity is connected with the gravitational constant by the equation

$$g = \frac{-GM}{r^2}$$

Explain the meanings of the terms in Italics. **(4)**

(b) Use the value of the gravitational field strength of the earth quoted in (a), together with the value of G, the gravitational constant and of the radius of the Earth (6.38 x 10^6 m) to calculate the mass of the Earth (g = 10 m s^{-2}).

(c) Calculate the Earth's gravitational field strength at a height of 0.12 x 10^6 m above the Earth surface.

(d) Explain briefly why an astronaut in a satellite orbiting the earth at this altitude may be described as weightless. **(6)**

(e) The value of the gravitational potential at a point in the Earth's field (ϕ) is given by the equation

$$\phi = -GM / r$$

Where, M is the mass of the earth and r is the distance of the point from the center of the Earth. (r is greater than the radius of the Earth.)

(f) Explain

(i)What is meant by the term gravitational potential?

(ii) Why the potential has a negative value?

(5)

(f) Use the expression given in (e) to calculate the gain in the potential energy of a satellite of mass 3000 kg between its launch and when it is at a height of 0.12×10^6 m above the Earth's surface.

(4)

5. (a) Stokes' law may represented by the equation shown below.

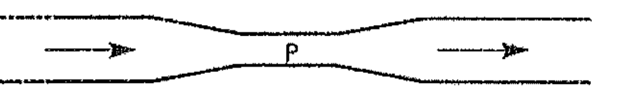
$$F = 6\pi\eta r v$$

(i) State the physical quantities represented by the symbols F, η, r and v and the conditions under which the relationship is valid.

(ii) Tiny spherical particles of alumina, having a wide range of radii, are stirred up in a beaker of water 8.0 cm deep. Draw a diagram showing the forces acting on one such particle, including the force of upthrust (equal to the weight of water displaced by the particle), shortly after stirring has ceased and the water has achieved a still condition. Hence determine the radius of the largest particle to remain in suspension after 24 hours. You may assume that the particles fall through the water with terminal velocity.

(Density of water = 1.0×10^3 kg m^{-3}, density of alumina = 2.7×10^3 kg m^{-3},
(coefficient of viscosity of water = 1.0×10^{-3} N s m^{-2}.) **(10)**

(b) State the equation of continuity for a compressible fluid flowing through a pipe. **(2)**



A horizontal pipe of diameter 36.0 cm tapers to a diameter of 18.0 cm at P. An ideal gas at a pressure of 2.00×10^5 Pa is moving along the wider part of the pipe at a speed of 30.0 m s^{-1}. (The pressure of the gas at P is 1.80×10^5 Pa). Assuming that the temperature of the gas remains constant calculate the speed of the gas at P. **(4)**

(c) State Bernoulli's equation for an incompressible fluid, giving the meanings of the symbols in the equation. **(4)**

(d) For the gas in (b) recalculate the speed at P on the assumption that it can be treated as an incompressible fluid, and use Bernoulli's equation to calculate the corresponding value for the pressure at P. Assume that in the wider part of the pipe the gas speed is still 30.0 m s^{-1}, the pressure is still 2.00×10^5 Pa and at this pressure the density of the gas is 2.60 kg m^{-3}.

(5)

6. (a) (i) Define the terms of surface tension, angle of contact of a liquid and explain the factors that effect on those quantities. **(4)**

(ii)The end of a clean glass capillary tube, having internal diameter 0.6 mm, is dipped into a beaker containing water, which rises up the tube to a vertical height of 5.0 cm above the water surface in the beaker. Calculate the surface tension of water.
(Density of water = 1000 kg m^{-3}, contact angle = 0)

(iii)What would be the difference if the tube were not perfectly clean, so that the water did not wet it, but had an angle of contact of 30° with the tube surface? **(6)**

(b) (i) The pressure difference p across a spherical surface of radius r between air and a liquid, where γ the surface tension of the liquid is given by

$$p = \frac{2\gamma}{r}$$

Show that this expression is consistent with γ being measured in Nm^{-1}. It can be shown that γ is also equal to the energy stored per unit area in the surface. Show that this is also consistent with γ being measured in Nm^{-1}.

(ii) Using the energy definition of γ given above calculate the energy stored in the surface of a soap bubble 2.0 cm in radius if its surface tension is 4.5 x 10^{-2} N m^{-1}. If the thickness of the surface is 6.0 x 10^{-7}m and the density of the soap solution is 1000 kgm^{-3}, calculate the speed with which the liquid fragments will fly apart when the bubble is burst. What assumptions have you made in your calculation? **(15)**

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