KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER
SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS

COURSE CODE: SPC 112

COURSE TITLE: GRAVITATION AND OSCILLATORY MOTION

DURATION: 2 HOURS

DATE: 1/10/2021 **TIME: 11:00-1:00PM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of **4** printed pages. Please Turn Over

1 atmosphere = $1\times10^5 N/m^2$
Radius of the moon $R_m = 3.84\times10^8 m$
Velocity of sound in air = 340m/s
Density of air = 1.29 kg/m^3
Viscosity of air = $1.81\times10^{-}5pa$
Acceleration due to gravity = 9.8 m/s^2
Density of water = 1000 kg/m^3
Young's modulus of bone compression = $9.4\times10^9 N/m^2$
Thermal conductivity of aluminium k_{Al} = 235 W/m/K
Thermal conductivity of copper k_{Cu} = 401 W/m/K
The surface tension of the soapy water $\gamma = 2.5\times10^{-2} N/m$
Linear expansivity of concrete $\alpha = 12\times10^{-6}(C^{\circ})^{-1}$
Specific latent heat of fussion of ice $L_f = 3.34\times10^5 J/kg$
Specific heat capacity of ice = 2100J/kg/K
Specific heat capacity of water C_w = 4200J/kg/K

QUESTION ONE (30 MARKS)

(a) State Kepler's Laws of planetary motion (2 Marks)

(b) What is *escape velocity*? Calculate the approximate value of the escape velocity (2 Marks)

(c) Distinguish between uniform velocity and instantaneous velocity (1 Mark)

(d) Prove that a gun will shoot three times as high when its angle of elevation is 60^0 as when it is 30^0, but will carry the same horizontal distance. (3 Marks)

(e) Show that the period of a conical pendulum is

$$T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$$

where all symbols carry their usual meaning. (3 Marks)

(f) Two masses of 0.5kg and 0.3kg are connected by a light inextensible string, which passes over a smooth pulley. If the system is released from rest with the string taut, find the acceleration of the system? (3 Marks)

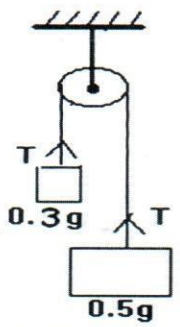

Figure 1: Two masses connected by a light inextensible string

(g) What is simple harmonic motion? Prove that the total energy of a body executing simple harmonic motion remains constant. (3 Marks)

(h) What force must be applied to a steel wire 6m long and diameter 1.6mm to produce an extension of 1mm (Young modulus for steel = $2.0 \times 10^{11} Nm^{-2}$). (2 Marks)

(i) Define surface tension of a liquid? Show that the work done to isothermally increase the surface area of a liquid is equal to the surface tension (2 Marks)

(j) Show that

$$y = A\sin\omega\left(\frac{x}{v} - t\right)$$ is equivalent to $y = A\sin(kx - \omega t)$ (2 Marks)

k) Define the following terms (3 Marks)

i) Periodic motion

ii) Period (T)

iii) Frequency (f)

l) Define the term damped harmonic motion (1 Mark)

m) Given the equation of motion:

$$m\ddot{x} = -kx - \beta\dot{x}$$

Show that the equation of damped harmonic motion is given by:

$$\ddot{x} + 2b\dot{x} + \omega^2 x = 0$$ (3 Marks)

QUESTION TWO (20 MARKS)

(a) Can an object (i) have zero velocity and still be accelerating? (ii) have a constant speed and still have a varying velocity? In each case give an example if your answer is yes; explain why if your answer is no. (2 Marks)

(b) 25g bullet moving horizontally with a velocity of 400m/s gets imbedded into a 4975g sand bag resting on a smooth surface. (6 Marks)

(i) Determine the speed acquired by the bag.

(ii) How much kinetic energy is lost in this process? In which forms does it occur?

(c) State Newton's Laws of motion (2 Marks)

(d) Prove Kepler's third law of planetary motion (4 Marks)

(e) Prove that a projectile launched at an angle θ has the same range as one launched with the same speed at angle $(90^0 - \theta^0)$ (6 Marks)

QUESTION THREE (20 MARKS)

(a) Distinguish between angular velocity and linear velocity (2 Marks)

(b) What is the speed of the tip of the minute hand of a clock, where the hand is of length 7cm? (4 Marks)

(c) For steel the breaking stress is 8.0 x 10^6 N/m^2 and the density is 8.0 x 10^3Kg/m^3. Find the maximum length of a steel wire which can be suspended without breaking under its own weight (g=10m/s^2). (6 Marks)

(d) Compute the acceleration of the system in figure 2 below (8 Marks)

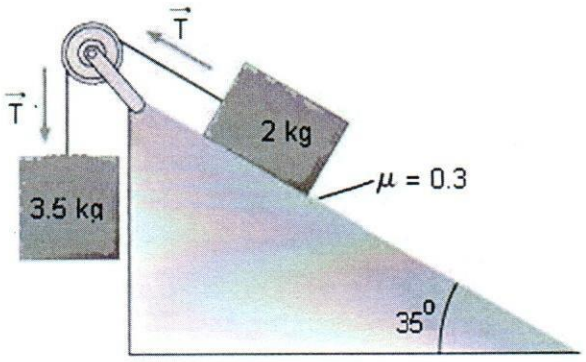

Figure 2: Two masses connected by a string through a pulley on an incline plane

QUESTION FOUR (20 MARKS)

(a) Show that the acceleration due to gravity g_h at height h above the earth's surface is given by

$$g_h = \frac{g_o}{\left(\frac{h}{R_e}+1\right)^2}$$

where g_o is the acceleration due to gravity on the earth and R_e is the radius of the earth. (4 Marks)

(b) Calculate the terminal velocity of a drop of water of radius 0.0015mm freely falling in air of negligible density. (5 Marks)

(c) Show that the velocity of a particle in simple harmonic motion is given by $\upsilon = \omega\sqrt{(r^2 - x^2)}$ where all symbols have their usual meaning (6 Marks)

(d) The mass of 0.5 kg is suspended on a spring and is performing SHM represented by the equation x = 3 sin (4t). Find the spring constant k and velocity at the equillibrium point. (4 Marks)

(e) Distinguish between streamline flow and turbulent flow (1 Mark)

QUESTION FIVE (20 MARKS)

(a) State the principle of continuity in fluids (1 Mark)

(b) The pressure and velocity at one end of a horizontal tube of non-uniform cross-section is 2.4×10^5Pa and 15.4 m/s respectively. What will be the velocity at the other end if the pressure at that end is 1.8×10^2Pa if the liquid used is water? (5 Marks)

(c) A mass of 50g is attached to a string of length 60cm. It is whirled in a circle in a vertical plane at 5 revolutions per second. Calculate the tension in the string when the mass is at the highest and lowest points of the circle (4 Marks)

(d) A car is travelling on a straight horizontal road. It moves off from rest with a constant acceleration of 0.50 $m.s^{-2}$. It stops accelerating after 16 s and moves with a constant velocity for a further 14 s. It then slows down uniformly and comes to rest 40 s after leaving its starting point. Draw a graph of velocity against time for the 40 s. Label the axes carefully. (4 Marks)

(e) From the fact that the moon orbits the earth in about 28 days, estimate the distance of the moon from the earth's surface. (4 Marks)

(f) State the Zeroth law of thermodynamics (2 Marks)