JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION (SCIENCE)

YEAR 1 SEMESTER 1

MAIN

REGULAR

COURSE CODE: SPH 101

COURSE TITLE: MECHANICS

EXAM VENUE: **STREAM: (BED SCI)**

DATE: **EXAM SESSION:**

TIME: 2:00HRS

Instructions:

1. **Answer question 1 (Compulsory) and ANY other 2 questions.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

QUESTION ONE (30 MARKS)

a. The Mechanical Energy E possessed by a body is given by

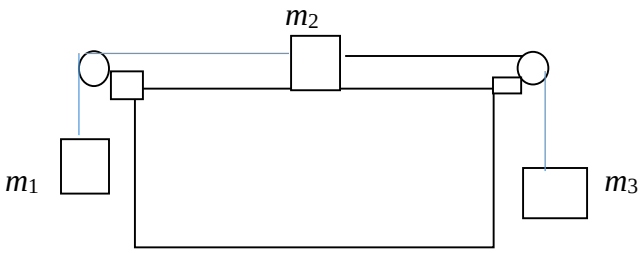
$$E = \frac{1}{2}mv^2 + mgh$$

Perform the dimensional analysis to obtain the dimensions of E. (4 marks)

b. A body initially moving at ***u*** accelerates uniformly at a to attain a final velocity ***v*** covering a distance ***s*** after a time interval ***t***. Show that the ***five*** are related by the formula

$$v(v+1) = u(u+1) + a(2s+t) \qquad \textbf{(5 marks)}$$

c. Three blocks of masses m_1= 28kg, m_2 =40 kg and m_3=80kg are connected by two light inelastic strings that passes over a frictionless pulleys, as shown in Figure 1. M_2 is sliding on a smooth plane.



Figure

Find the common acceleration of the three blocks and the tensions on the two strings. **(5 marks)**

d. Show that the elastic potential energy possessed by spring is given by. $P.E = \frac{1}{2}ke^2$

(4 marks)

e. An 18 g bullet is fired at a velocity of 1400m/s into a 15kg monkey suspended freely on a tree by a rope 2m long. The bullet gets embedded into the monkey and the two swing as a simple pendulum. Determine the initial centripetal force experienced by the monkey-bullet system at the beginning of the swing. (4 marks)

f. State the three Kepler's laws of planetary motion. (3marks)

g. In a crash test, a car of mass 1.50×10^3 kg collides with a wall and rebounds. The initial and final velocities of the car are v_i=15.0 m/s and v_f = -2.60 m/s, respectively. If the collision lasts for 0.150 s, find

i) the impulse delivered to the car due to the collision (3marks)

ii) the size and direction of the average force exerted on the car (3 marks)

QUESTION TWO **(20 Marks)**

a. From the top of a 120m tall building, John releases a stone to freely fall to the ground. At the same time Onthuga throws a ball at 150m/s vertically upwards from the base of the building along the same path of the falling stone. Find the velocities of each object at the time of their collision. (5 marks)

b. A projectile is launched with an initial velocity ***u*** at an angle θ to the horizontal towards the sky. It attains a vertical rise y and a horizontal displacement (Range) x.

I) Show that

i. The maximum height risen, is given by $y_{\max} = \frac{u^2 \sin^2 \theta}{2g}$ (3 marks)

ii. The horizontal range is given by $R = \frac{u^2 \sin 2\theta}{g}$ (3 marks)

iii. Its trajectory is parabolic (4 marks)

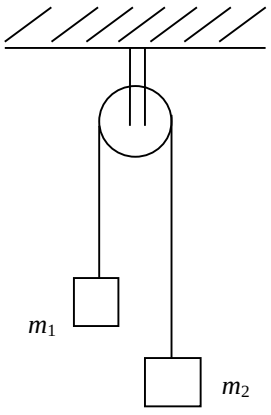
II) Determine the length of the direct line joining the point of the maximum height to the point at which it hits the ground in terms of ***u,*** *θ and g*

(5 marks)

QUESTION THREE **(20 Marks)**

a. Two bodies are such that the mass of one is four times the mass of the other. A common force F acts on each at a time, determine the ratio of their accelerations 3 marks

b. Two objects of mass *m*1 and *m*2, with *m*2 >*m*1, are connected by a light, inextensible cord and hung over a frictionless pulley, as shown in figure 3. Both cord and pulley have negligible mass.



Show that the magnitude of the acceleration of the system a, and the tension T in the cord are given by:

$$a = \left(\frac{m_2 - m_1}{m_2 + m_1} \right) g \qquad T = \left(\frac{2m_1 m_2}{m_1 + m_2} \right) g$$ (6 marks)

c. A revolver of radius 14.0m accelerates uniformly from a speed of 600rpm to a speed of 2000rpm in 15.0 s. Find

(i) the angular acceleration (2 marks)

(ii) the tangential acceleration, (3 marks)

(iii) the total acceleration acceleration (3 marks)

(iv) the total number of revolutions made within this time. (3 marks)

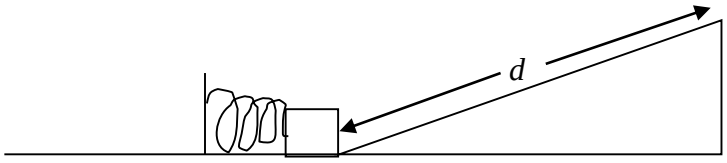
QUESTION FOUR (20 Marks)

a. State the work-energy theorem (1 mark)

b. Show that the kinetic energy possessed by a body of mass m moving from rest to a final velocity v is given by $K.E = \frac{1}{2}mv^2$ (4 marks)

c. A marble is released at the rim of a semi-spherical hollow dish to fall towards the centre of the dish while rolling freely along its internal surface. Given that the dish has a radius of 12cm, determine the maximum centripetal acceleration acquired by the marble. (5 marks)

d. A 5-kg block rests on a horizontal, frictionless surface as shown in Figure 3. The block is pressed back against a spring having a constant of k =625 N/m, compressing the spring by 30.0 cm. Then the block is released.



Find the velocity with which the block leaves the spring 3

(a) Find the maximum distance *d* the block travels up the frictionless incline if it slopes at 45.0° to the horizontal. 4 marks

(b) How fast is the block going when halfway to its maximum height? 4 marks

QUESTION FIVE **(20 Marks)**

a. State the universal gravitational law (2 marks)

b. Applying Newton's second law of motion and the universal gravitational law show that

i. The gravitational potential energy is given by $P.E_g = -\frac{GMm}{R}$ (3 marks)

ii. The gravitational acceleration g, is given by $g = \frac{GM}{R^2}$, hence evaluate the value of gravitational acceleration of the planet Mars. (5 marks)

c. Mercury, Earth and the Sun are lying along a straight line at a particular time. Find the point between Mercury and the earth at which an object must be placed so that the net gravitational force exerted by Mercury and the Earth on that object is zero. (5marks)

d. Derive the Kepler's third law of gravitation in the form $T^2 = \frac{4\pi^2}{GM_s}R^3$ (5 marks)