JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE WITH IT

1st YEAR 1ST SEMESTER 2016/2017 ACADEMIC YEAR

MAIN CAMPUS

COURSE CODE: SPH 101

COURSE TITLE: MECHANICS

EXAM VENUE: **STREAM: (BSc.)**

DATE: 19/04/16 **EXAM SESSION: 9.00 – 11.00 AM**

TIME: 2 HOURS

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.**

THE following constants might be useful

gravitational acceleration $g=9.81m/s^2$

Graviatational Constant $G=6.673X10^{-11}kg^{-1}m^3s^{-2}$

Average Distance between the Sun and the Earth $R_{ES}=1.496x10^{11}m$

Radius of the earth $R_E=6.38x10^6\ m$

Mass of the earth $M_E=5.98x10^{24}m$

Mass of the sun $Ms=1.991x10^{30}kg$

QUESTION ONE (Compulsory) (30 Marks)

a. The period of a simple pendulum, defined as the time necessary for one complete oscillation, is measured in time units and is given by $T = 2\pi\sqrt{\frac{l}{g}}$, where l is the length of the pendulum and g is the acceleration due to gravity. Show that this equation is dimensionally consistent. (3 marks)

b. A train running along a straight track at 30m/s is slowed uniformly to a stop in 44seconds. Find the acceleration and the stopping distance. (4 marks)

c. Two balls are such that one is four times the mass of the other. A uniform force F acts on each at equal time intervals. Find the ratio of their accelerations. (3 marks)

d. A block with mass m_1= 4.00 kg and a ball with mass m_2 =7.00 kg are connected by a light string that passes over a frictionless pulley, as shown in Figure 1. The coefficient of kinetic friction between the block and the surface is 0.25

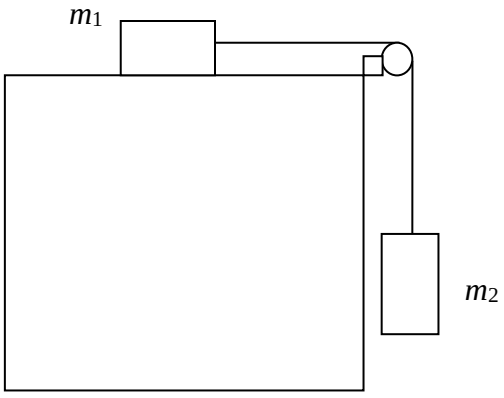


Figure 1

Find the common acceleration of the two objects and the tension in the string. **(5 marks)**

e. Thierry Henry strikes a ball towards the goal keeper at 300m/s. The keeper holds the ball for just 0.5 seconds and repulses it back at 250m/s.

i) the impulse delivered to the ball (3marks)

ii) the magnitude and direction of the average force exerted on the ball by the goal keeper (3 marks)

f. Two objects attract each other with a gravitational force of magnitude 1.0 x10^8 N when separated by 20.0 cm. If the total mass of the objects is 5.00 kg, what is the mass of each? (4 marks)

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

QUESTION TWO (20 Marks)

a. A projectile is launched straight up at 60.0 m/s from the top of a cliff of height of 80.0 m, at the edge of a sheer cliff. The projectile rises then falls, just missing the cliff and hitting the ground down at the bottom of the cliff.

Find (i) the maximum height of the projectile above the point of firing. (2 marks)

(ii) the time it takes to hit the ground at the base of the cliff, and (3 marks)

(c) the velocity with which it hits the ground. (4 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. Show that

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

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

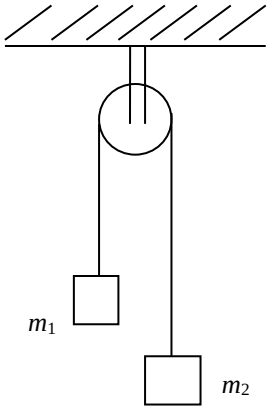
iii. The vertical rise ***y*** as a function of the range x is given by the equation

$$y = (\tan\theta)x - \left(\frac{g}{2u^2 \cos^2 \theta}\right)x^2$$

(5 marks)

QUESTION THREE **(20 Marks)**

a. Two objects of mass $m1$ and $m2$, with $m2 > m1$, 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:

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

(8 marks)

b. A revolver of radius 4.0m accelerates uniformly from a speed of 300rpm to a speed of 1500rpm in 5.0 s. Find

(i) the angular acceleration (3 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)

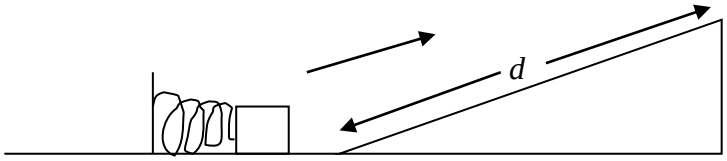
QUESTION FOUR **(20 Marks)**

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. An 8.00-kg block drops straight down from a height of 1.00 m, striking a platform spring having force constant 1.0x 10^3 N/m. Find the maximum compression of the spring 3 marks

a. A 0.500-kg block rests on a horizontal, frictionless surface as in Figure 3. The block is pressed back against a spring having a constant of k =625 N/m, compressing the spring by 10.0 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 30.0° 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 $P.E_g = -\frac{GM_E m}{R_E}$ (3 marks)

ii. The gravitational acceleration g, is given by $g = \frac{GM_E}{R_E^2}$, hence show that the earths gravitational acceleration $g=9.81m/s^2$ (5 marks)

c. Find the point between Earth and the Sun at which an object must be placed so that the net gravitational force exerted by Earth and the Sun on that object is zero. (4 marks)

d. Derive the Kepler's third law of gravitation in the form $T^2 = \frac{4\pi^2}{GM_s} R_{ES}^2$, hence compute T for the earth (6 marks)