MACHAKOS UNIVERSITY

University Examinations 2017/2018

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

SPH 100: MECHANICS I

DATE: 14/12/2017 **TIME: 2.00-4.00 PM**

INSTRUCTIONS TO CANDIDATES

Answer **QUESTION ONE** and **ANY OTHER TWO** questions.

Question 1 carries **30**mks and the others carry **20**mks each.

YOU MAY USE:

You may need to use the following constants

- Density of water = $1.0 \times 10^3 kg/m^3$
- Acceleration due to gravity g = $9.8\ m/s^2$
- Universal gravitational constant G = $6.67 \times 10^{-11}\ Nm^2kg^{-2}$
- Mean radius of the earth R_e= 6400 km
- Mass of the Earth, Me, = 5.98×10^{24} kg
- Permittivity of free-space, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m

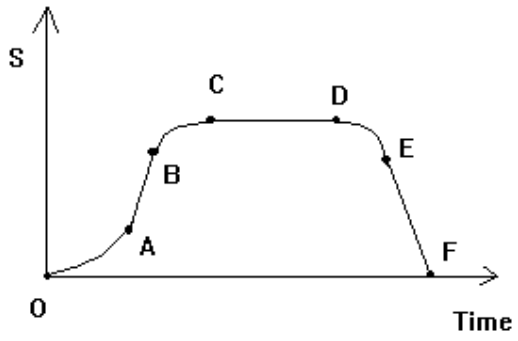
QUESTION ONE (COMPULSORY) (30 MARKS)

(a) Use dimensional analysis to derive the dimensions of the following quantities;
- (i) Tan θ (1 mark)
- (ii) Acceleration (1 mark)
- (iii) Momentum (2 marks)
- (iv) Energy (2 marks)

(b) You are in a laboratory doing a practical to prove a physics concept. Identify any three sources of errors that might result to a systematic error. (3 marks)

(c) A particle is moving with a uniform speed on a circular path, state with reason whether it has acceleration or not. (1 mark)

(d) Describe the motion of a body that is represented by the following displacement-time graph for sections: **OA, AB, CD and EF** (4 marks)



(e) State the three laws of friction (3 marks)

(f) Differentiate between linear and angular velocity and show that $v = \omega r$ where all the symbols have their usual meanings (4 marks)

(g) State the three Kepler's laws of gravity (3 marks)

(h) What is escape velocity? Determine the escape velocity for a body from the earth given the radius, R of the earth is $6378km$ and the mass of the moon is $5.98\times10^{21}kg$. (3 marks)

(i) A 3 m ladder is inclined at an angle of 30° to a frictionless wall. What is the maximum value of the coefficient of static friction (μ_s) with the ground? (3 marks)

QUESTION TWO (20 MARKS)

(a) (i) State and write a mathematical expression for Newton's law of Universal Gravitation (3 marks)

(ii) Show that at a height, h above the earth's surface, the acceleration due to gravity g_h is related to the acceleration due to gravity at the earth's surface, g by the equation,

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

where R_e is the radius of the earth (5 marks)

(iii) What is the value of acceleration due to gravity at an altitude of 500 km? Radius of the earth is 6400km. (3 marks)

(b) (i) Show that the horizontal range (R) of a projectile is given by,

$$R = \frac{u_0^2 \sin 2\theta}{g},$$

Where all the symbols have their usual meaning. (3 marks)

(ii) If the angle of projection is 45° and the range is 10km, calculate the initial speed and the time of flight of the projectile. (3 marks)

(c) Show that bodies project at 30^0 and 60^0 have the same range. (3 marks)

QUESTION THREE (20 MARKS)

(a) A stone of mass 0.4kg is tied to a string of length 0.5m and whirled in a circle. If the stone revolves uniformly and makes one complete revolution per second, calculate its acceleration and the force exerted on the stone by the string. (4 marks)

(b) In designing a curved road, engineers consider the speed *v* of a car, angle of banking θ and the coefficient of friction μ between the car tyres and the road. The radius of curvature of the road bend is chosen to be large enough so that the car will be able to move around smoothly in a part-circle. Derive the formula for the radius of curvature in terms of the speed of the car, banking angle and the coefficient of friction. (7 marks)

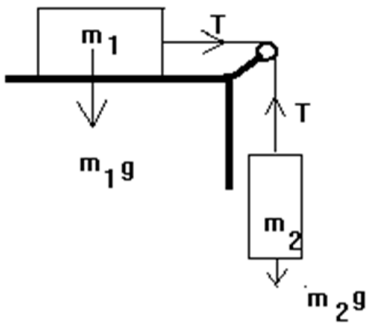
(c)Civil engineers generally *bank* curves on roads in such a manner that a car going around the curve at the recommended speed does not have to rely on friction between its tyres and the road surface in order to round the curve. Suppose that the radius of curvature of a given curve is r = 60 m, and that the recommended speed is $v = 60km/hr$. At what angle θ should the curve be banked? (3 marks)

(d) For a pulley system with blocks with masses m_1 and m_2, derive the expressions for;

(i) Acceleration of the system (3 marks)

(ii) Tension on the strings (3 marks)

Assume a massless string



QUESTION FOUR (20 MARKS)

a) State Newton's laws of motion (3 marks)

b) Derive the total weight experienced by a person on a lift under the following conditions;

(i) The lift is in upward motion (2 marks)

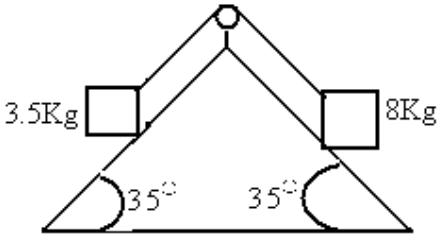
(ii) The lift is in downward motion and (2 marks)

(iii) Under free-fall (2 marks)

c) Compute the least acceleration with which a 45kg woman can slide down a rope if the rope can withstand a tension of only 300N. (3 marks)

d) A constant force **F** acts on a 5kg object and reduces its velocity from 7m/s to 3m/s in a time of 3s. Find F. (3 marks)

e) Two blocks of mass 3.50 kg and 8.00 kg are connected by a string of negligible mass that passes over a pulley as shown below. The inclines have a coefficient of friction, $\mu_k = 0.6$.



Find

(i) The magnitude of the acceleration of each block and (3 marks)

(ii) The tension in the string. (5 marks)

QUESTION FIVE (20 MARKS)

a) A vehicle starts from rest with initial velocity u and attains a final velocity v after time t.

(i) Derive the three equations describing its motion. (5 marks)

(ii) Write the equivalent equations describing the motion of a rocket launched from a space-science station? (3 marks)

b) A metallic slab with mass 600 kg falls from the roof-top of a building under construction. Calculate the distance at which the slab attains a velocity of 25 m/s. (3 marks)

c) A 3.2 kg sphere with a speed of 8 m/s hits another stationary sphere. If the collision is inelastic and the speed of the spheres after collision is 2.1 m/s

(i) What is the mass of the stationary sphere? (3 marks)

(ii) What is the kinetic energy lost after collision? (3 marks)

(iii) What is the total momentum after collision? (3 marks)