TECHNICAL UNIVERSITY OF MOMBASA

A Centre of Excellence

Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS AND PHYSICS

APRIL 2016 SERIES EXAMINATION

UNIT CODE: SMA 2273 UNIT TITLE: APPLIED MATHEMATICS 1

MAIN EXAMINATION

TIME ALLOWED: 2HOURS

INSTRUCTIONTO CANDIDATES:

You should have the following for this examination

- Mathematical tables
- Scientific Calculator

This paper consists of **FIVE** questions

Answer question **ONE (COMPULSORY)** and any other **TWO** questions

Maximum marks for each part of a question are as shown

QUESTION ONE (30 MARKS) COMPULSORY

a. Given that$r = e^{-t}costi + e^{-t}sintj + e^{-t}k$. Find the magnitude of
   i. Velocity (2 marks)
   ii. Acceleration (2 marks)

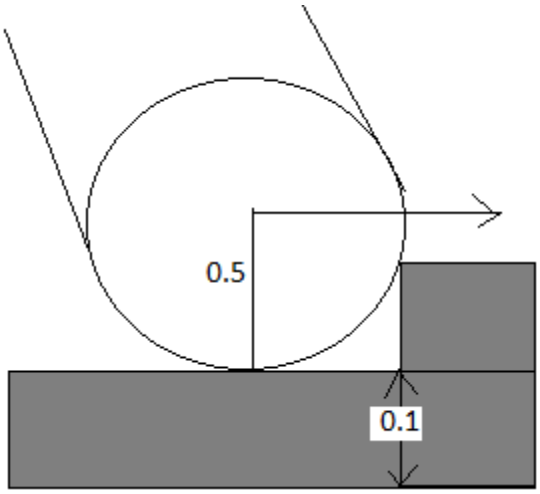
b. derive the equation for the oscillation of a simple pendulum using dimensional analysis (4 marks)

c. Calculate the force required to pull a block of mass 10kg along a horizontal surface if the coefficient of static friction is 0.5. take g=9.8m/s^2 (3 marks)

d. A force given by 6tN is acting on a particle whose mass is 12kg. if it starts from rest determine the work done by the force in the first 4 seconds (3 marks)

e. State Newton's first law of motion and Newton's third law of motion and briefly explain their consequences (4 marks)

f. Figure below shows a drum of mass 150kg and radius 0.5m being pulled by horizontal force F against a step 0.1m high. What initial force is just sufficient to turn the drum so that it raises over the step.



(4 marks)

g. A ball of mass 35g travelling horizontally at 20m/s strikes a wall at right angles and rebounces with a speed of 16m/s. find the impulse exerted on the wall. (4 marks)

h. A girl of mass 50kg jump onto the ground from a 2m wall. Calculate the force on her when she lands
   i. By bending her knees and stops in 0.2sec (2 marks)
   ii. Keeping her legs straight and stops in 0.05 sec (2 marks)

QUESTION TWO (20 MARKS)

a. A motor cycle stunt rider rides off the edge of a cliff with a horizontal velocity of magnitude 5m/s. Find the riders position and velocity after ¼ seconds (6 marks)

b. A pilot of a private plane flies 20.0km in a direction 60^0 north of east, then 30km straight east, then 10.0km straight north. How far and in what direction is she from the starting point (7 marks)

c. A particle moves in a circle of radius 20m. if its tangential speed 40m/s. find

i. The angular speed (velocity) (1 marks)

ii. Angular acceleration and Normal acceleration (2 marks)

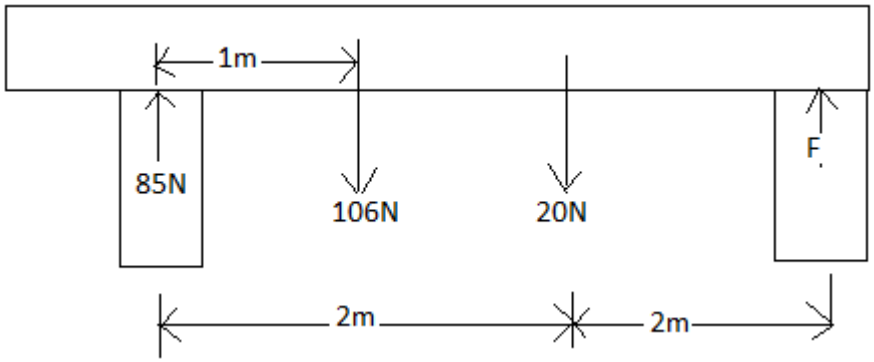
iii. The arc length covered and the arc subtended in time 5 seconds. (3 marks)

iv. The number of rounds in t=50 seconds. (1 marks)

QUESTION THREE (20 MARKS)

a. Two masses of 0.5kg and 0.25kg 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 each mass and the distance travelled in 1 second from rest. (6 marks)

b. Find the unknown force F, if the system below is in equilibrium(3 marks)



c. For a body that starts with initial velocity u and constant acceleration and to a final velocity v. derive the three equations of linear motion (4 marks)

d. A lorry of mass 2000kg moving at 10m/s on a horizontal surface is brought to rest in a distance of 12.5m by the brakes being applied.

i. Calculate the average retarding force F (5 marks)

ii. What power must the engine produce if the lorry is to travel up a hill of 1 in 10 at a constant speed of 10m/s; if frictional resistance is 200N (5 marks)

QUESTION FOUR (20 MARKS)

a. A ball is thrown vertically upwards with a velocity of 30m/s. calculate
   i. Maximum height reached (2 marks)
   ii. Tim taken for it to return to the ground (2 marks)

b. Two particles whose position vectors are

$$r_1 = ti - t^2 j + (2t + 3)k$$
$$r_2 = (2t - 3t^6)i + 4tj - 4t^3 k$$

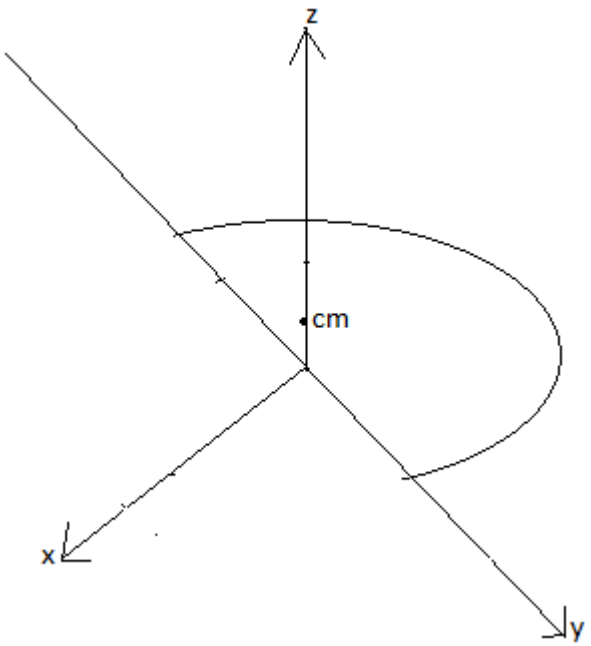
Find the relative velocity and acceleration of the second particle with respect to the first particle when t=1(3 marks) (6 marks)

c. Show that $F = yxi + xzj + xyk$ is a conservative force field and hence find the potential function associated with this field; with zero value at the point (1, 1, 1) (4 marks)

d. Find an expression for the drag force on a smooth sphere of diameter D, moving with a uniform velocity v in a fluid density ρ and dynamic viscosity μ (6 marks)

QUESTION FIVE (20 MARKS)

a. A slender metal arch, thicker at the bottom than at the top, lies along the semi circle in the yz plane. Find the centre of the arch mass if the density at the point (x, y, z)=2-z (4 marks)



b. Find the components of the vectors that is 13 units along and makes an angle of 22.6^0 with z axis and whose projection in the XY plane makes an angle of 37^0 with the x axis (3 marks)

c. Derive the equation of the path of a projectile

$y = tanx - \frac{gx^2 sec^2 x}{2v^2}$ (3 marks)

d. A particle moves in a space with its position vector at any time t given by

$$ti + \frac{1}{2}t^2 j + tk$$

Find

i. The velocity vector and speed of the particle (2 marks)

ii. The acceleration and its magnitude (2 marks)

iii. Tangential and Normal acceleration 4 marks)

iv. The curvature and radius of curvature to any point in the space curve (2 mks)

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