TECHNICAL UNIVERSITY OF MOMBASA
FACULTY OF APPLIED AND HEALTHY SCIENCES
DEPARTMENT OF MATHEMATICS AND PHYSICS
UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS AND BACHELOR OF TECHNOLOGY IN RENEWABLE ENERGY AND ENVIROMENTAL PHYSICS

APS 4104: MECHANICS I

SPECIAL/ SUPPLIMENTARY EXAMINATIONS

SERIES: September 2018

TIME: 2 HOURS

DATE: SEPTEMBER 2018

INSTRUCTION TO CANDIDATES

You should have the following for this examination.
-Answer Booklet, examination pass and student ID.
This paper consists of FIVE questions.
Answer question ONE (COMPULSORY) and ANY other TWO questions.
The maximum marks for each question is shown.
Do not write on the question paper.
Mathematical tables and scientific calculators may be used.
The following constants may be useful:
Gravitation acceleration, g = 9.89 m/s^2

QUESTION ONE (30 mks)

a) Define the following terms as used in mechanics. (4mks)
   (a) Impulse
   (b) Projectile
   (c) Linear motion
   (d) Circular motion

b) A driver of a car travelling at 72km/hr observes a traffic light 300 m ahead of him turning red. The traffic light is timed to remain red for 20 seconds before it turns green. If the motorist wishes to pass the light without stopping to wait for the light to turn green, determine;

(i) The required uniform acceleration of the car. (2mks)
(ii) The speed with which the motorist crosses the traffic light. (3mks)

c) Mosiori, who is standing 4.8m from a wall at Nyari bridge throws a stone so that it may just clear 3.6m high wall. If the stone landed 3.6m away from the wall but on the other side of the wall, calculate the minimum velocity he must have used to project the stone. (9mks)

d) (i) State Newton's second law of motion? (1mk)

e) An object of mass M_1= 2kg is allowed to slide with kinetic energy on a horizontal plane surface that was very smooth with friction having a coefficient of μ_k.

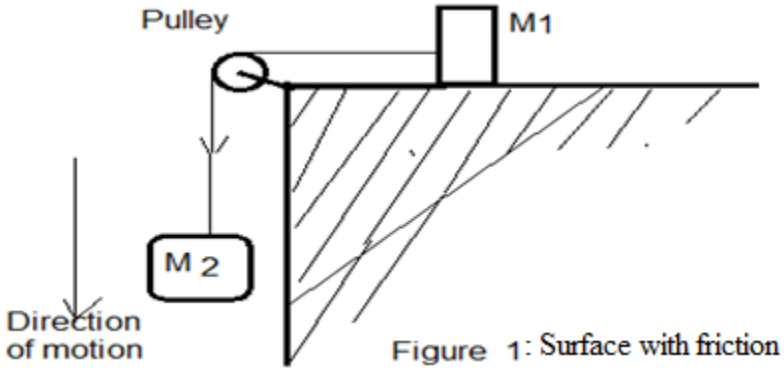

Figure 1: Surface with friction

If the solid objects were attached together with a massless string and the second object had a mass of 8kg;

(i) Show that the acceleration experienced by the mass, M_1 can be given as;

$$a = \left[\frac{M_2 - \mu_k M_1}{M_2 + M_1}\right] g(1 + \mu_k)$$ where g = gravitation force (6mks)

(ii) Show that in the presence of kinetic friction having a coefficient of μ_k, tension in the string can be given by

$$T = \left(\frac{M_2 M_1}{M_2 M_1}\right) g(1 + \mu_k)$$ where g = gravitation force (5mks)

QUESTION TWO (20 mks)

a) Define the following terms as used in dimensional analysis. (3mks)
(i) Unit of a physical quantity
(ii) Fundamental physical quantity
(iii) Derived physical quantity

b) Show that the equation;

Power = Force x Velocity

is an homogeneous equation in its basic dimensions. (4mks)

c) A race car accelerates uniformly from a velocity of 4.0m/s to a velocity of 60m/s in just 5 seconds while travelling counter clockwise around a circular track of radius 4.0 x 10^2 m. When the car attains a velocity of 50.0m/s, find;
(i) the magnitude of the car's centripetal acceleration. (2mks)
(ii) the car's angular velocity. (2mks)
(iii) the magnitude of the car's tangential acceleration. (2mks)

(iv) the magnitude of the total acceleration of the constant tangential and centripetal accelerations. (2mks)

d) (i) List four limitations of dimensional analysis. (4mks)
(ii) State Newton's third law of motion. (1mk)

QUESTION THREE (20 mks)

a) Define and explain any three types of collision objects can undergo. (6mks)
b) A 75 kg fisherman in a 125kg boat throws a package of mass, 15kg horizontally with an initial velocity of 4.5 m/s. Neglecting water resistance and if the boat was at rest before the package was thrown, find the final velocity of the boat after the package was thrown. (4mks)
c) A pick up truck of mass, 1.8×10^3 kg is initially travelling eastwards at velocity of 15.0m/s while a compact car with a mass of 900 kg is travelling westwards with a velocity of 15 m/s. If the two vehicles collide head-on and become entangled, find
(i) The velocity of the entangled vehicles after collision. (2mks)
(ii) The change in velocity of each vehicle. (2mks)
(iii) The change in kinetic energy of the system of both vehicles. (2mks)
d) Two billiard balls of identical masses move towards each other. Assume that the collision between the is perfectly elastic. If the velocities of the balls are 3.0 cm/s and – 2.0 cm/s respectively and there is no friction and also the balls do not rotate, what are their velocities after collision? Show how you arrive at your answer. (4mks)

QUESTION FOUR (20 mrks)

a) Define the term centripetal force (1mk)
b) A compact disc rotates uniformly from rest till it attains an angular velocity of 3.4 rad/s in a time of 0.892 seconds.
(i) Find the angular acceleration of the disc. (2mks)
(ii) If the radius of the disc is 4.45 cm, find;
(a) Its tangential displacement of a microbe riding on the rim of the disc when t= 0.892 seconds . (2mks)
(b) The tangential velocity V_c, at t= 0.892 seconds. (2mks)
(c) The magnitude of the tangential acceleration of the microbe at the given time (t=0.892 seconds). (2mks)
c) An Atwood machine composed of a massless pulley and two solid object of masses, M1 = 5kg and M2 = 3kg were connected through a massless string as shown in figure 2.

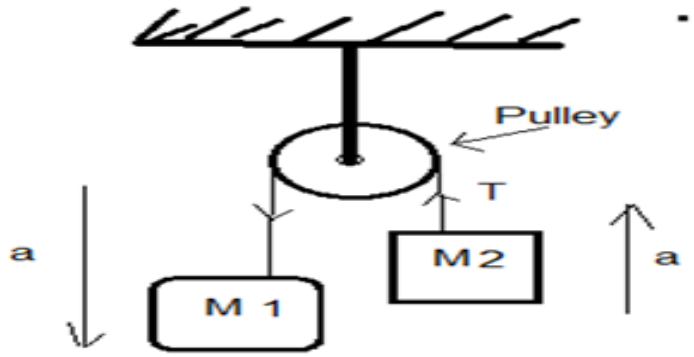

Figure 2 Frictionless Atwood Machine

(i) Show that if mass, M_1 is heavier than M_2, the acceleration, *a*, of the system can be given by;

$$a = \left[\frac{M_2 - M_1}{M_2 + M_1}\right]g$$ where g = gravitation pull. (4mks)

(ii) Determine the acceleration for this system. (2mks)

(iii) Show that the tension, T, in the string can be expressed as;

$$a = \left[\frac{2M_2M_1}{M_2 + M_1}\right]g$$ where g = gravitation pull. (3mks)

(iv) Determine the tension experienced by the string in the system. (2mks)

QUESTION FIVE (20 mks)

a) (i) Define the term speed. (1mk)

(ii) Sketch a speed-time graph for a car moving at a constant speed. (2mks)

b) A car starts from rest and travels as shown in the velocity-time graph in figure 3. Determine the distance covered by the car. (2mks)

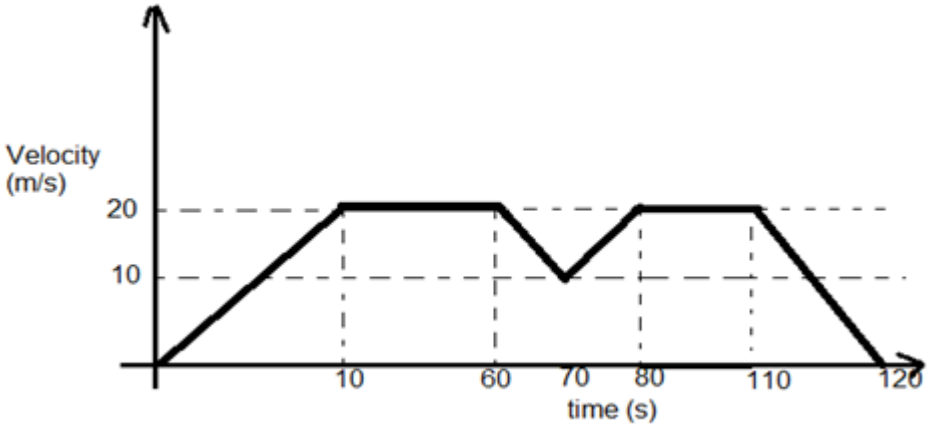

Figure 3 Velocity- time graph for a car

c) Two cars standing a distance apart starts moving towards each other with velocities of 1m/s and 2m/s along a straight road. What is their velocities at which they approach each other. (3mks)

d) A particle starts from origin at t = 0 seconds with a velocity of 5m/s and moves in the x-y plane under action of a force which produces a constant acceleration of *(3.0i +2.0j)* m/s.
   (i) What is the y-component of the particle at the instant its x-component is 84.0 metres? (6mks)
   (ii) What is the velocity of the particle at this time? (3mks)

e) Explain the following types of friction: (3mks)
   (i) Static friction
   (ii) Kinetic friction
   (iii) Fluid friction