



MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR
BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

SPH 106: MECHANICS

DATE: 11/8/2021

TIME: 8:30 -10:30 AM

INSTRUCTIONS:

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

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

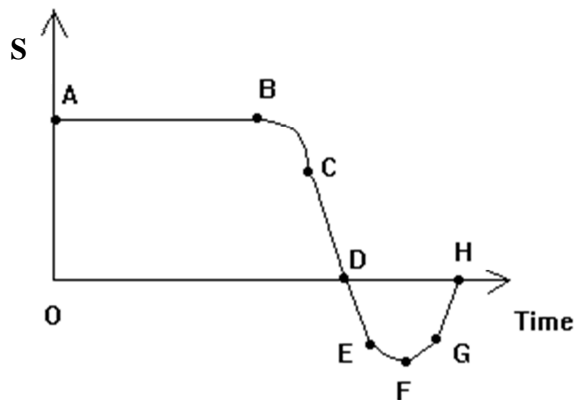
YOUMAYUSE:

You may need to use the following constants

- Density of water= $1.0 \times 10^3 \text{ kg/m}^3$
- Acceleration due to gravity, $g=9.8 \text{ m/s}^2$
- Universal gravitational constant $G=6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$
- Mean radius of the earth $R_e=6400 \text{ km}$
- Mass of the Earth, $M_e, = 5.98 \times 10^{24} \text{ kg}$
- Permittivity of free-space, $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$

QUESTION ONE

- (a) Use dimensional analysis to derive the dimensions of the following quantities;
- i) Sine (1 mark)
 - ii) Force (2 marks)
 - iii) Acceleration (1mark)
- (b) Differentiate between adhesive and cohesive properties of matter (2 marks)
- (c) (i) Distinguish between vector and scalar quantities giving an example of each. (3 marks)
- (ii) Find the angle between the vectors $\mathbf{A} = 2\mathbf{i}+2\mathbf{j}-2\mathbf{k}$ and $\mathbf{B} = 3\mathbf{i}+4\mathbf{j}+5\mathbf{k}$ (4 marks)
- (d) While writing its mathematical expression, state the universal law of gravitation (3 marks)
- (e) Describe the motion of a body that is represented by the following Displacement-time graph for sections: **OA, AB, BD, CD, EF and OH** (6 marks)
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- (f) A spring has a spring constant of 40 N/m. If it is stretched by 0.3 cm from its equilibrium, how much work is done? (3 marks)
- (g) Write Poiseuille's equation and state one application (3 marks)
- (h) Differentiate between laminar and unsteady flows (2 marks)

QUESTION TWO

- (a) 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 (8 marks)

- (iii) What is the value of acceleration due to gravity at an altitude of 500 km? Radius of the earth is 6400 km (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 110 m, calculate the initial speed and the time of flight of the projectile. (3 marks)

- (c) Show that bodies projected at 30° and 60° have the same range. (3 marks)

QUESTION THREE

- a) In cartesian co-ordinate system, show that

(i) $\mathbf{i} \cdot \mathbf{i} = \mathbf{j} \cdot \mathbf{j} = \mathbf{k} \cdot \mathbf{k} = 1$ (2 marks)

(ii) $\mathbf{i} \cdot \mathbf{j} = \mathbf{j} \cdot \mathbf{k} = \mathbf{k} \cdot \mathbf{i} = 0$ (2 marks)

(iii) $\mathbf{i} \times \mathbf{j} = \mathbf{j} \times \mathbf{k} = \mathbf{k} \times \mathbf{i} = \mathbf{i}$ (2 marks)

(iv) $\mathbf{j} \times \mathbf{i} = -\mathbf{k}$, $\mathbf{k} \times \mathbf{j} = -\mathbf{i}$, $\mathbf{i} \times \mathbf{k} = \mathbf{j}$ (2 marks)

- (a) A 2000 kg vehicle with a speed of 25 m/s strikes another moving car with a speed of 16 m/s whose mass is 1200 kg.

- i) What is the velocity of the junk? (4 marks)

- ii) Find the fractional part of the kinetic energy that the cars have after collisions. (4 marks)

- iii) What is the total momentum after collision? (4 marks)

QUESTION FOUR

- (a) State the three Kepler's laws of gravity (4 marks)
- (b) What is escape velocity? Determine the escape velocity for a body from the earth's surface. (4 marks)
- (c) A wire of a length 1m and diameter of 0.4mm is hung from a ceiling. Find the extension caused in the wire, by attaching a weight of 100N, if the material of the wire has the Young's modulus of $200 \times 10^{11} \text{Nm}^{-2}$. (4 marks)
- (d) Discuss any 2 factors affecting the surface tension in a liquid. (4 marks)
- (e) Determine the curl and div. of $\mathbf{r}$, where $\mathbf{r} = 2xy^2\mathbf{i} - 3zx^3\mathbf{j} + 5zy\mathbf{k}$ (4 marks)

QUESTION FIVE

- (a) 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 $r = 60 \text{ m}$, and that the recommended speed is $v = 60 \text{ km/hr}$. At what angle θ should the curve be banked? (4 marks)
- (b) Derive the expression for total energy per unit volume of a fluid flowing in an unequal horizontal pipe (6 marks)
- (c) A drop of water of radius 0.0015 m is falling in air. If the coefficient of viscosity of air is $1.8 \times 10^{-5} \text{ Kg/ms}$, what will be the terminal velocity of the drop? (Density of water is 1000 Kg m^{-3} , neglect density of air). (4 marks)
- (d) Prove the consistency of Kepler's third law (6 marks)