



MACHAKOS UNIVERSITY

UNIVERSITY EXAMINATIONS 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES
FIRST YEAR FIRST SEMESTER SUPPLEMENTARY EXAMINATION FOR
BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS
ENGINEERING

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

ECU 101: PHYSICS FOR ENGINEERS I

DATE: 24/9/2019

TIME: 2:00 – 4:00 PM

INSTRUCTIONS:

Answer QUESTION ONE which is **COMPULSORY** 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

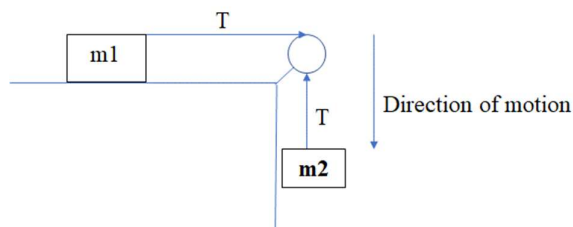
- Density of water= $1.0 \times 10^3 \text{ kg/m}^3$
- Acceleration due to gravity $g=9.8 \text{ m/s}^2$
- Universal gravitational constant $G=6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$
- Mean radius of the earth $R_e=6400 \text{ km}$
- Mass of the Earth, $M_e, = 5.98 \times 10^{24} \text{ kg}$
- Mass of the Sun, $M_s, = 1.98 \times 10^{30} \text{ kg}$
- Permittivity of free-space, $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$

QUESTION ONE (COMPULSORY)

- a) Two vectors have non-zero magnitude. Under what condition will their dot and cross product be zero? 3 marks
- b) Find the angle between $\mathbf{a}$ and $\mathbf{b}$ in the following cases:
 $\mathbf{a} \cdot \mathbf{b} = 2$ where $|\mathbf{a}| = 2$ and $|\mathbf{b}| = 3$ 3 marks
- c) An electron in a cathode ray tube (CRT) accelerates from 2.00×10^4 m/s to 6.00×10^6 m/s over length 1.50 cm.
- i) How long does the electron take to travel this 1.50 cm? 1 mark
- ii) What is its acceleration? 2 marks
- d) State Kepler's Laws of planetary motion. 3 marks
- e) Derive the three equations of motion for a space rocket projected from a NASA station to space. 4 marks
- f) What is simple harmonic motion? Prove that the total energy of a body executing simple harmonic motion remains constant. 3 marks
- g) State Stoke's law 2 marks
- h) Describe two similarities of gravitational and Coulombic forces. 4 marks
- i) The mass of a bicycle and its rider is 100kg and he wants to take a turn of radius 80m with speed of 20m/s. If the coefficient of friction between the tyres and the road is $\mu = 0.6$ then calculate the angle with which he must lean to negotiate the turn safely. Will the rider skid? 3 marks
- j) State Zeroth law of thermodynamics 1 mark
- k) A stone of mass 0.4 kg 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;
- i) its acceleration 2 marks
- ii) force exerted on the stone by the string. 1 mark

QUESTION TWO

- a) What physical designs dictate the difference in speeds between a fighter-jet and a helicopter? 2mks
- b) Describe how a driver can steer a car traveling at constant speed so that (i) the acceleration is zero or (ii) the magnitude of the acceleration remains constant. 3 marks
- c) A car runs at a constant speed of 15m/s for 300 seconds and then accelerates uniformly to a speed of 25m/s over a period of 20 seconds. This speed is maintained for 300 seconds and then accelerates uniformly in 30 sec. Draw a velocity time graph to represent the journey described above. From the graph (i) find the acceleration while the body changes from 15m/s to 25m/s. (ii) the total distance traveled in the time described. (iii) The average speed over the time described. 6 marks
- d) Two blocks of mass m_1 and m_2 are connected by a massless string that passes over a frictionless pulley. The inclines are frictionless. Find (i) the acceleration of each block and (ii) the tension in the string. 5 marks



- e) A projectile is launched at an initial velocity u_0 and at angle θ relative to the horizontal surface.

Show that;

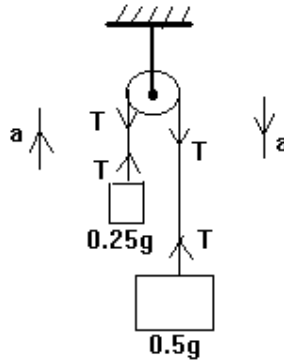
- i) The range, $R = \frac{u_0^2 \sin 2\theta}{g}$ 3 marks
- ii) The range, R is maximum when $\theta = 45^\circ$ 2 marks

QUESTION THREE

- a) A person weighs a fish of mass m on a spring scale attached to the ceiling of an elevator. Show that if the elevator accelerates either upward or downward, the spring scale gives a reading that is different from the weight of the fish. Suppose the elevator cable breaks, so that the elevator and its contents are in free-fall. What happens to the reading on the scale? 4 marks
- b) Derive the equation for escape velocity and determine the escape velocity for a body on the earth's surface. 7 marks
- c) A trailer of mass 6000 kg rams into an oncoming car of mass 1600 Kg. The velocity of the trailer before impact is 80 km/hr and the initial velocity of the car is 140 km/hr. Find the final velocity of the system of the junk. Is KE conserved in this system? 5 marks
- d) The equation of motion of a transverse wave in a string is given by, $y = 6.0 \sin(4.0\pi t + 0.02\pi x)$ where y is in cm and t in sec. Find the amplitude, frequency, Period, velocity of the wave. 4 marks

QUESTION FOUR

- a) Define surface tension and state 3 factors that affect it. 5 marks
- b) State and write the mathematical expression for Newton's law of universal gravitation. 3 marks
- c) *Two masses of 0.5 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 sec. from rest.* 5 marks



- d) Show that for an orbiting satellite around the earths,

$$T^2 \propto r^3$$

4mks

- e) An aluminium stick of length 1.5 m is cooled from 20°C to -180°C . Find the final length if its coefficient of linear expansion is $23 \times 10^{-6}/\text{K}$

3 marks

QUESTION FIVE

- a) State Bernoulli's theorem and the law of continuity 2 marks
- b) A 0.12 kg mass attached to a spring oscillates with amplitude $A = 0.05\text{ m}$ and a maximum speed of 0.17 m/s. Find;
- The spring constant
 - The period
 - The maximum acceleration 2 marks
- c) A rod 4.2 m long and 0.50 cm^2 in cross-sectional area is stretched 0.20 cm under a tension of 12.0 N. Calculate;
- Stress and strain
 - Young's modulus 2 marks
- d) A drop of water of radius 0.0015 m is falling in air. If the coefficient of viscosity of air is $1.8 \times 10^{-5}\text{ Kg/msec}$, what will be the terminal velocity of the drop? (Density of water is 1000Kg m^{-3} , neglect density of air). 3mks
- e) In a water supply system, a horizontal pipe of radius 10 mm is joined to a horizontal pipe with radius 15 mm with both pipes at the same height. A fluid flows through both pipes from the narrow pipe to the wider pipe with an average velocity of 3 mm/s in the narrow pipe. Assume that the fluid has zero viscosity and the density of the fluid is equal to the density of water.
- What is the volume flow rate? 1 mark
 - What is the average speed for the wider pipe? 2 marks
 - What is the pressure difference between the two pipes? 2 marks