MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL ENGINEERING)

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

BACHELOR OF SCIENCE (MECHANICAL ENGINEEERING)

ECU 101: PHYSICS FOR ENGINEERS I

DATE: 14/03/2022 **TIME: 11:00-1:00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Constants

Acceleration due to gravity, $g = 9.81\ m/s^2$

$R = 8.3\ JK^{-1}mol^{-1}$,

$NA = 6.02 \times 10^{23}\ mol^{-1}$

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

(a) Define the following terminologies in physics

i. Young's modulus (2 marks)

ii. Inertial frame of reference (2 marks)

(b) A gas bubble from an explosion under water oscillates with a period T proportional to $p^a d^b E^c$ where p is the static pressure, d is the density of water and E is the total energy of explosion. Find the values of a, b and c. (5 marks)

(c) A mass of 8.00 kg is attached to a piece of inelastic string of length 4.00 m, and rests on a smooth horizontal plane. The other end of the string is fastened to the plane. The mass is set in motion so that it performs horizontal circles on the plane. The maximum tension that the string can provide is 700 N.

i. Draw a diagram showing the forces that acts on the mass. (Air resistance is negligible. (2 marks)

ii. Calculate the maximum linear speed the mass can move at without breaking the string. (3 marks)

iii. What maximum angular velocity does this equate to? (3 marks)

(d) In an explosion, an object splits into two parts whose masses are in the ratio 2:3. Assuming that the object was motionless before the explosion, and that the larger mass moves with speed 16 ms^{-1} after the explosion, calculate the speed of the smaller mass. (4 marks)

(e) As part of a quality control check, a manufacturer of washing line subjects a sample to a tensile test. The sample of washing line is 12 m long and of constant circular cross-section of diameter 5.0 mm. The manufacturer measures an extension of 42 mm under a stretching load of 72 N. The manufacturer also breaks the line under a load of 240 N. Calculate the Young modulus of the washing line. (4 marks)

(f) If $F_W = 40$ N in the equilibrium situation shown in Figure 1.1, find F_{T1} and F_{T2}. (5 marks)

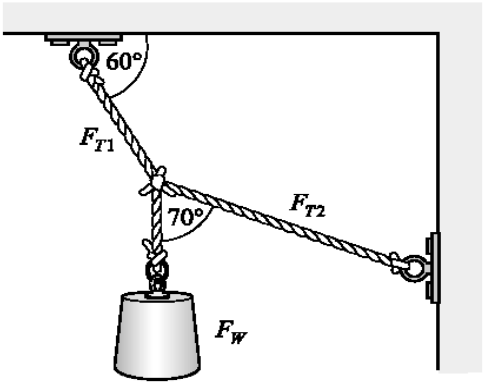

Figure 1. 1

QUESTION TWO (20 MARKS)

(a) Describe the stress – strain graph for a ductile material. (4 marks)

(b) A force of 300 N is sufficient to keep a 100 kg wooden crate moving at constant velocity across a wooden floor. What is the coefficient of kinetic friction? (3 marks)

(c) A ball is thrown upwards at an angle of 30^{o} to the horizontal and lands on the top edge of a building that is 20 m away. The top edge is 5.0 m above the throwing point. How fast was the ball thrown? (6 marks)

(d) An object of mass 2.0 kg is rotated in a vertical circle on a cord of length 1.0 m. The cord will break if the tension in it becomes 500 N.

The speed of rotation is gradually increased from zero.

i. Find the angular velocity at which the string breaks. (4 marks)

ii. Draw a diagram to show the position at which the string breaks and the subsequent motion of the object. (3 marks)

QUESTION THREE (20 MARKS)

(a) Describe the following terms

i. Isothermal changes (2 marks)

ii. Adiabatic changes (2 marks)

(b) The first law of thermodynamics may be written as $\Delta U = Q + W$. State the meanings of each of the terms in the equation (3 marks)

(c) Air is enclosed in a container that has a moveable piston. The container has an initial volume of 7.50×10^{-4} m^3. A constant force of 125 N is applied to the piston so that it moves a distance of 4.50 cm, compressing the gas. The pressure of remains at 100,000 Pa throughout the compression. Calculategas r

i. the work done in moving the piston. (3 marks)

(d) the final volume of the gas, stating any assumption that you make. (5 marks)

The displacement of a particle moving under uniform acceleration is some function of the elapsed time and the acceleration. Suppose we write this displacement $s = ka^m l^n$, where k is a dimensionless constant use dimensional analysis to determine the values of m and n. (5 marks)

QUESTION FOUR (20 MARKS)

(a) Define the following terms as used in materials

i. Breaking stress (2 marks)

ii. Yield point (2 marks)

(b) State any three assumptions of the kinetic theory of gases. (3 marks)

(c) A container of volume 1.0×10^{-3} m^3 has hydrogen at a pressure of 3×10^5 Nm^{-2} and temperature 20°C.

[Molar mass of hydrogen is 2g]

Calculate

i. The number of molecules of hydrogen in the container. (4 marks)

ii. The v_{RMS} of the molecules of hydrogen (3 marks)

(e) When certain rocket engines are fired, they produce a total thrust force of 4.2×10^6 N. In test firing, the rocket is held to the launch pad by 6 bolts, each of diameter 8.0 cm. the Young's modulus of steel is 2.0×10^{11} Pa. The breaking stress of steel is 5.0×10^8 Pa.

i. Calculate the strain for each bolt during the test. (3 marks)

ii. Determine the minimum number of bolts that could have been used for testing the engines. (3 marks)

QUESTION FIVE (20 MARKS)

(a) Define the following terms

i. Impulse (2 marks)

ii. Centripetal force (2 marks)

(b) State two main differences between an elastic collision and inelastic collision. (2 marks)

(c) In a game of pool-table, a player wishes to sink a target ball 2 in the corner pocket, as shown in Figure 5.1. If the angle to the corner pocket is 35°, at what angle θ is the cue ball 1 deflected? Assume that friction and rotational motion are unimportant and that the collision is elastic. (4 marks)

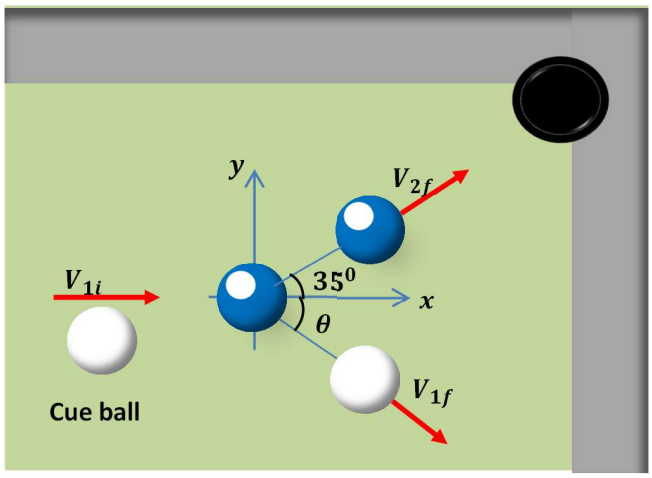

Figure 5.1

(d) A small object of mass 200 g is attached to the end of a light string of length 40 cm. The string is fastened at its other end, and the object is set in motion so that it moves in a vertical circle. When the string makes an angle of 60^o with the downward vertical, the object moves with speed U ms^{-1}. ($g = 9.81$ N kg^{-1})

(i) Find the speed of the object at the highest point in terms of U. (4 marks)

(ii) Find the tension at the highest point in terms of U. (3 marks)

(iii) Hence give the minimum possible value of U. (3 marks)