UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, DECEMBER 2015

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	ENGINEERING MECHANICS AND MATERIALS SCIENCE
COURSE CODE:	EE201
TIME ALLOWED:	THREE HOURS

INSTRUCTIONS:

1. **There are five questions in this paper. Answer QUESTION 1 and ANY OTHER THREE QUESTIONS, making a total of four questions**
2. **Each question carries 25 marks.**
3. **Marks for different parts of a question are shown in the right hand margin.**
4. **A sheet containing useful formulae, some of which you may need, is attached at the end.**

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THIS PAPER CONTAINS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION ONE (COMPULSORY) ***(25 marks)***

(a) For the six main classes of engineering materials, use your own experience to rank them approximately:

(i) By stiffness (modulus). *(3 marks)*

(ii) By thermal conductivity. *(3 marks)*

(b) Distinguish between the following terms as used in engineering mechanics

(i) Fatigue and creep. *(3 marks)*

(ii) Inertia and impulsive force. *(3 marks)*

(iii) Angle of friction and coefficient of friction. *(3 marks)*

(iv) Brittleness and hardness. *(3 marks)*

(c) Briefly discuss the material properties which the following items should have:

(i) Key components of a bicycle. *(3 marks)*

(ii) Key components of a mains electrical plug. *(4 marks)*

QUESTION TWO ***(25 marks)***

(a) A sphere of radius 200 mm and weight 20 N is suspended against a smooth vertical wall by a string of length 200 mm. The string joins a point on the wall to a point on the surface of the sphere.

(i) Draw the arrangement and explain why the external forces acting on the sphere must be concurrent. *(4 marks)*

(ii) Find the angle of inclination of the string with the horizontal. *(2 marks)*

(iii) Determine the tension in the string *(2 marks)*

(iv) Determine the reaction of the wall. *(2 marks)*

(b) A vertical pile of mass 120 kg is driven 90 mm into the ground by the blow of a 500-kg hammer which falls through 800 mm. Assuming the hammer and pile remain in contact, determine:

(i) the velocity of the hammer just before impact, *(3 marks)*

(ii) the velocity immediately after impact, and *(3 marks)*

(iii) the resistive force of the ground, assuming it to be uniform. *(4 marks)*

(c) A ball of mass 100 g is moving with a velocity of 6 m/s when it strikes a stationary ball of mass 300 g. The velocity of the 100 g ball after impact is 2.5 m/s in the opposite direction it was moving before impact. Determine the velocity of the 300 g ball after impact. *(5 marks)*

QUESTION THREE ***(25 marks)***

A ladder 5 m long and of weight 250 N is placed against a wall in a position where its inclination to the vertical is 30°. The coefficient of static friction for both the contact surfaces of the ladder, that is the wall and the floor, is 0.2. A man weighing 800 N climbs the ladder. At what position will he induce slipping of the ladder? *(25 marks)*

QUESTION FOUR *(25 marks)*

(a) A motor applies a constant torque to turn an initially stationary wheel of diameter 0.5 m. The wheel acquires a speed of 150 revolutions per minute (r.p.m.) in 5 minutes. Determine:

(i) The angular acceleration of the wheel. *(5 marks)*

(ii) The total number of revolutions made by the wheel during this time. *(3 marks)*

(iii) The tangential speed of a point on the wheel at 150 r.p.m. *(2 marks)*

(b) A system of frictionless pulleys carries two weights W_1 and W_2 of 100 N and 60 N respectively as shown in Fig. Q4b. The strings are inextensible and the pulleys are weightless. If the weights are held at rest and then released, find:

(i) The accelerations of the two weights. *(10 marks)*

(ii) The tension in the string. *(2 marks)*

(iii) The distance travelled by each weight 1.5 seconds from rest. *(3 marks)*

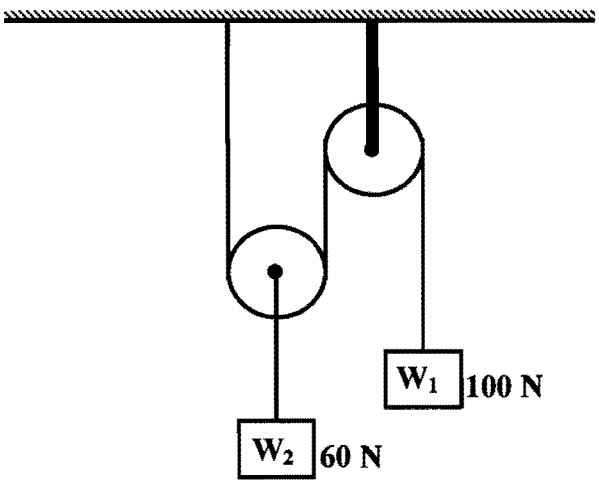

Fig. Q4b

QUESTION FIVE ***(25 marks)***

(a) From a stress/strain point of view briefly explain what you understand by each of the following properties of metals:

(i) Strength *(3 marks)*

(ii) Elasticity *(3 marks)*

(iii) Plasticity *(3 marks)*

(iv) Ductility *(3 marks)*

(b) A reinforced concrete column is 300 mm by 300 mm in cross-section. The column is built with 8 steel bars, each of 20 mm diameter. The column carries a load of 360 kN. Find the stresses in concrete and in the steel bars. Take Young's Moduli as $E_{steel} = 210$ GN/m^2 and $E_{concrete} = 14$ GN/m^2. *(13 marks)*

LIST OF FORMULAE, SOME OF WHICH YOU MAY NEED

$g = 9.81\ \text{m/s}^2$

$v = u + at, \quad \omega_2 = \omega_1 + \alpha t$

$s = ut + \frac{1}{2}at^2, \quad \theta = \omega_1 t + \frac{1}{2}\alpha t^2$

$v^2 = u^2 + 2as, \quad \omega_2^2 = \omega_1^2 + 2\alpha\theta$

$F = \mu N$

Work done $= F \times d = T \times \theta$

P.E $= mgh$

K.E. $= \frac{1}{2}mv^2 = \frac{1}{2}I\omega^2$

Accelerating force $= m \times a$

Torque $= F \times x = I_o\alpha$

Power $= T\omega = Fv$

$v = r\omega, \quad a_R = r\omega^2 = \frac{v^2}{r}, \quad a_T = r\alpha$

Momentum $= mv = I\omega$

Energy stored $= \frac{1}{2}\frac{\sigma^2}{E}\ \text{J/m}^3$

$\sigma_i = \frac{PE_i}{A_1E_1 + A_2E_2}, \quad i = 1,2$