UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, FIRST SEMESTER, NOV/DEC 2010

FACULTY OF SCIENCE

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.
2. Each question carries 25 marks.
3. Marks for different parts of a question are shown in the right hand margin.

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THIS PAPER CONTAINS SIX (6) PAGES INCLUDING THIS PAGE

QUESTION 1

Figure 1 shows a ladder of weight 400 N resting on two surfaces at point A and B. Dimensions are as indicated. The coefficient of friction at all contacting surfaces is 0.5 and the gravitational constant is 9.81 m/s.

If a man can walk up the ladder, a distance of 6 metres, before slip occurs,

A) draw the free body diagram of the ladder, and [5 marks]

B) determine the weight of the man in kilograms. [15 marks]

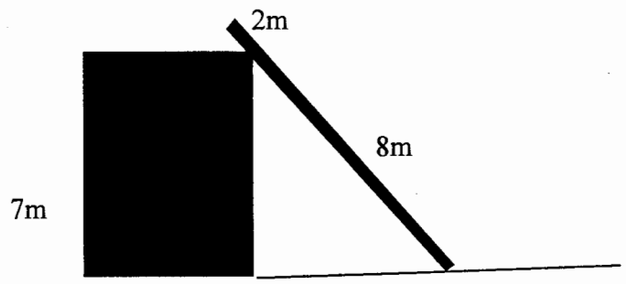


Figure 1

QUESTION 2

A) A circular cable has a tensile force of 66 N applied to it and this force produces a stress of 3 MPa in the cable. Determine the diameter of the cable. [3 marks]

B) Determine by resolution of forces the resultant of the following three coplanar forces acting at a point : 10kN acting at 30^0 to the horizontal ; 20 kN acting at 120^0 to the horizontal; 30 kN acting 300^0 to the horizontal. [11 marks]

C) An experiment is required to obtain the value of the coefficient of friction μ, this is achieved by placing the mass on an inclined plane and then increasing the value of an angle θ until the mass just moves down the plane.

If the experimentally obtained value for θ were 16.7^0 . What is the value of μ. [6 marks]

[Note: There is no pulling or push force. Mass m is unknown and should not be calculated.]

QUESTION 3

A) In a test on a simple machine, the effort/load graph was a straight line of the form $\boldsymbol{F_e = aF_l + b}$. Two values lying on the graph were at $F_e = 30\ N$, $F_l = 300\ N$ and at $F_e = 60\ N$, $F_l = 400\ N$. The movement ratio of the machine was 8.33. Determine the limiting force ratio and the limiting efficiency of the machine. [8 marks]

B) A screw-jack is being used to support the axle of a car, the load on it being 2.7kN. The screw jack has an effort of effective radius 160 mm and a single-start square thread, having a lead of 5 mm. Determine the efficiency of the jack if an effort of 60 N is required to raise the car axle. [8 marks]

C) Define or state the following :

(i) Elasticity, [2 marks]

(ii) Hooke's law, and [1 mark]

(iii) Young's modulus. [1 mark]

QUESTION 4

(a) Briefly explain each of the following terms as used in the description of properties of a material:

(i) Hard *(2 marks)*

(ii) Ductile *(2 marks)*

(iii) Plastic *(2 marks)*

(iv) Dielectric *(2 marks)*

(v) Stiff *(2 marks)*

(b) Explain the differences between the following material processes:

(i) Drilling, milling, turning *(3 marks)*

(ii) Casting, molding, rolling *(3 marks)*

(c) An office rubber band with rectangular cross-section 3mm x 1.5 mm forms a circular loop of diameter 30 mm when not stretched. The rubber band is stretched and then used to hold together a roll of paper of 50 mm diameter.

(i) Ignoring the effect of the thickness of the band, by how much has the band been stretched? *(3 marks)*

(ii) Calculate the energy stored in the rubber band if E for rubber is 10^{-3} GPa. *(6 marks)*

QUESTION 5

(a) Use the material property chart given below to find, from among the materials that appear on it,:

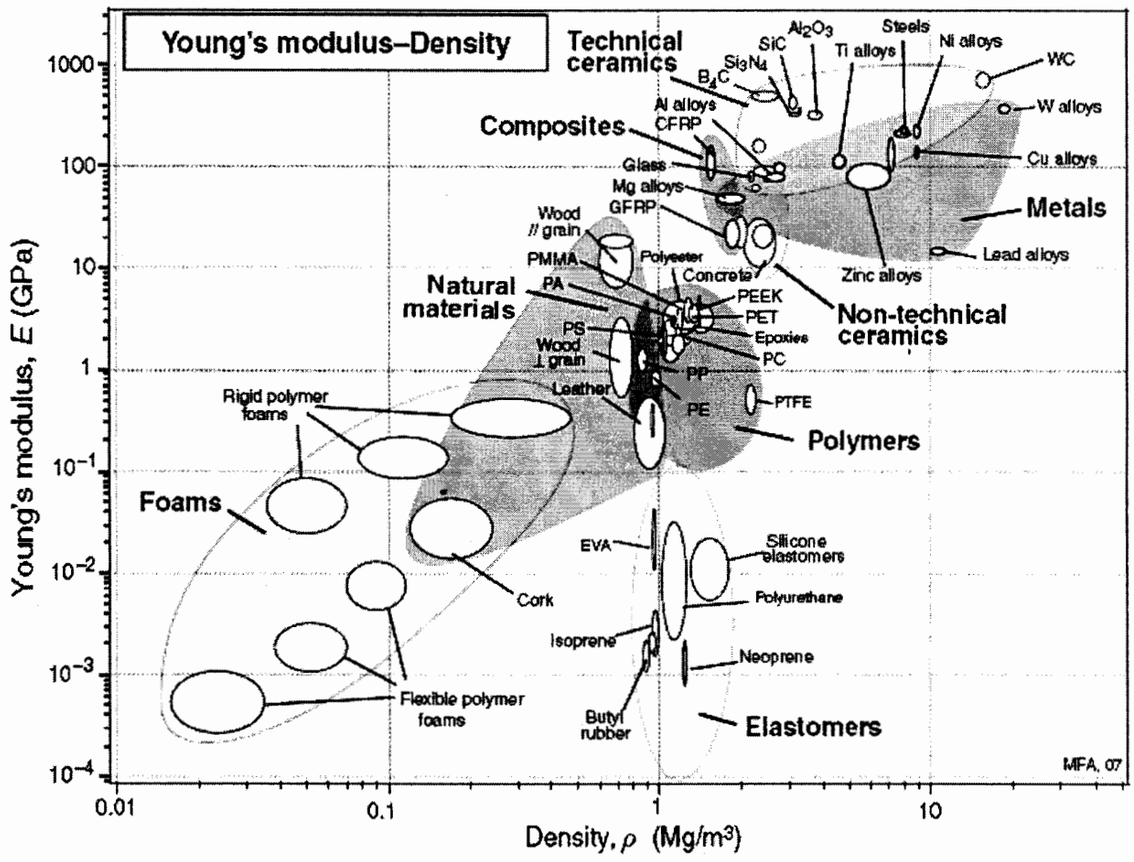
(i) The material with the highest density. *(1 mark)*

(ii) The metal with the lowest modulus. *(1 mark)*

(iii) The polymer with the highest density. *(1 mark)*

(iv) The approximate ratio of the modulus of woods measured parallel to the grain and perpendicular to the grain. *(2 marks)*

(v) The approximate range of modulus of elastomers. *(2 marks)*



(b) (i) You are asked to design a fuel-saving cooking pan with the goal of wasting as little heat as possible while cooking. How would you choose a material to use and what constraints would you think must be met?

(4 marks)

(ii) Many objects are these days made out of plastics. As a materials science student could you explain why bicycles are not made out of plastics. *(4 marks)*

(c) A compound bar is made up of two strips of aluminium alloy (25 mm wide by 10 mm thick) fixed rigidly either side of a steel strip (25 mm wide by 5 mm thick), as shown in Figure Q5. The bar carries a load of 1 kN.

Data: For steel: E = 200 GPa For Aluminium: E = 70 GPa

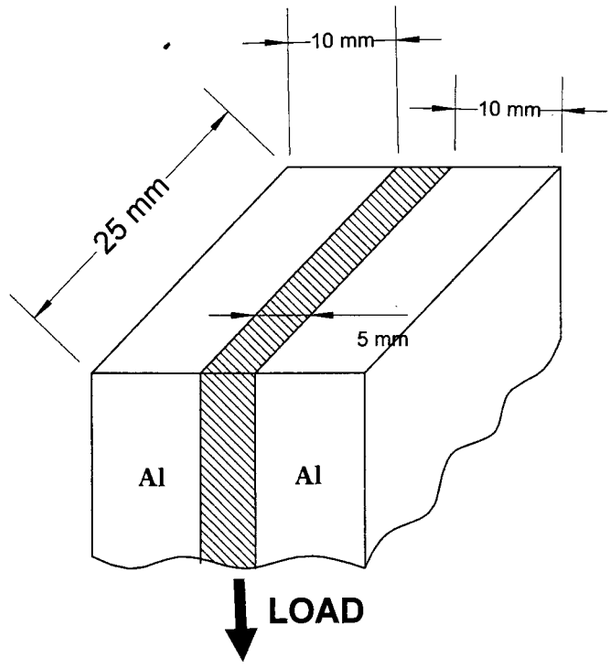


Figure Q5

Determine:

(i) The combined modulus of the bar. Hint: Assume that the contribution of each metal to the combined Modulus is proportional to its volume (thickness in this case)

(4 marks)

(ii) The strain in the bar. *(3 marks)*

(iii) The stress in each element of the bar. *(3 marks)*