THE OPEN UNIVERSITY OF SRI LANKA

DIPLOMA IN TECHNOLOGY - LEVEL 01

FINAL EXAMINATION 2005/2006

CEX1330/CEF1301 - ENGINEERING PROPERTIES OF MATERIALS

Time allowed: 3 Hours Registration No.:

Date: 20th April, 2006 Time: 13:30-16:30

Note: The Periodic table is given on the last page for reference.

PART A:

Answer all questions. Each question carries 2.5 marks and the mark for Part A makes up 30% of the total mark.

1. A child swinging on a swing travels back and forth at a steady pace. Explain what determines the period of his motion?
2. Explain why bicycling to the top of a mountain is much harder than rolling back downhill. At which place you have the highest gravitational potential energy.
3. Have you ever slipped on a banana skin? Describe why slipping occurs when you step on to a banana skin.
4. List the desirable engineering properties that a steel drill bit should possess.
5. Conductivity of semi conductors increases with temperature, while the good conductors decrease marginally with increase of temperature. Explain why.
6. Ropes made of Coir are used to draw water from wells. The short strands of coir are entwined to form the rope. Explain what gives the rope high-tension capacity. Discuss why coir ropes fail faster when wet than dry.
7. Materials such as Silicon and Germanium can be made to conduct electricity even at normal temperatures. Explain how you achieve this.
8. Ripples (waves like surfaces) on asphalted roads can be found after a certain period of usage by vehicular traffic. Explain the phenomenon behind formation of ripples.
9. As you drive up and down in the mountains, you may feel a popping in your ears as air moves to equalize the pressures inside and outside your eardrum. Discuss the reason behind these pressure changes.
10. Explain why mild steel is a ductile material while cast iron is brittle.
11. Explain what is an 'isotope'. Give two examples.

12. Some times engineers intentionally add impurities to metals to get better mechanical properties. List two examples where a metal is intentionally made impure.

PART B:

Answer 4 questions. Each question carries 17.5 marks and the mark for part B makes up 70% of the total mark.

1.

a) An astronaut weighs himself before leaving the earth and finds that his mass is 95.0 kg. Suppose that he is in a spacecraft in space, far from any celestial object that exerts significant gravity,

i) Determine the weight of the astronaut when he is in space. (2 marks)

ii) Would the astronaut have a mass when he is in space? (2 marks)

If the astronaut is now on the surface of the moon;

iii) Determine the weight of the astronaut on the surface of the earth. (2 marks)

iv) If the gravitational acceleration on the moon is one- sixth of that on earth, compute his weight on the moon. (2.5 marks)

b) An aluminium block of mass 25g suspended by a string at the top is totally submerged in water. The density of Aluminium is 2700kg/m^3.

i) Sketch the free body diagram for the block indicating all the forces. (2 marks)

ii) Determine the volume of the Aluminium block. (2 marks)

iii) Compute the up-thrust exerted by the fluid on the block. (2.5 marks)

iv) Determine the tension in the string when the block is totally submerged in water. (2.5 marks)

2.

a) Friction forces are those forces that two surfaces in contact exert on each other to oppose the sliding of one surface over the other.

i) A force is applied to a textbook, which is kept on a horizontal table. Show on a plot how the pushing force varies with time. Indicate all important points. (3 marks)

ii) State the law of dry friction. Define the terms in the expression. Explain the difference between static and dynamic friction. (3 marks)

iii) Explain why it is necessary to have sufficient tread on all wheels of a car especially on a rainy day. (2 marks)

iv) A 50 N box is slid straight across the floor at constant speed by a force 25 N, as shown in figure Q2.

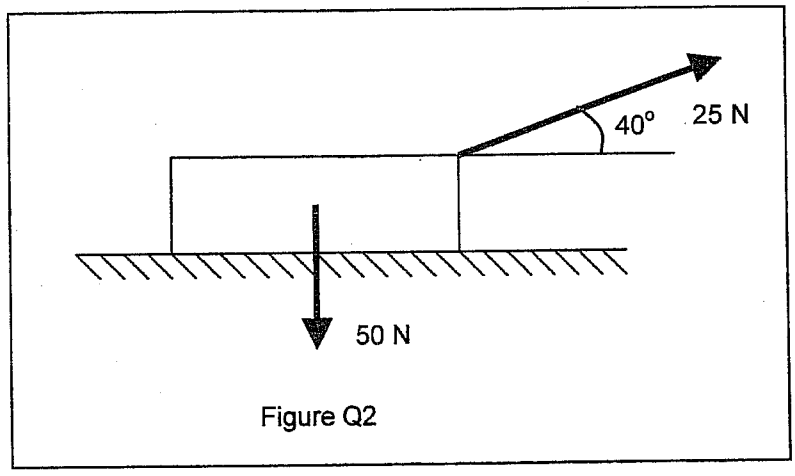

Figure Q2

i. Draw a free body diagram and mark all the forces. (1 mark)

ii. Determine the coefficient of kinetic friction between the box and the floor. (2 marks)

v) State two instances that the friction becomes a hindrance and a necessity in everyday life. (2 marks)

b) A lubricant is a substance used to reduce friction by preventing direct contact of rubbing surfaces.

i) State two examples where water is used as a lubricant. (2 marks)

ii) Boric powder is a solid lubricant used to apply on carom boards. List reasons why water or vaseline can not be used in place of boric powder on carom boards. (2.5 marks)

3. A steel wire of diameter 0.4m and initial length 2.0m is hung vertically from a fixed support. When an 80 N weight is suspended from the lower end of the wire so that it hangs freely, the wire extends by 6.4mm.

i) State Hooks law and define the terms used in the expression. (2 marks)

ii) Calculate the strain and stress in the wire. (3 marks)

iii) Determine the Young modulus for the material of the wire. (2 marks)

iv) Draw stress – strain diagram for the steel wire and mark the following;

a) Proportional limit/elastic limit/range where plastic yielding takes place

b) Yield point/point of rupture

(3.5 marks)

v) Draw a stress-strain diagram for vulcanised rubber and compare it with the diagram in (iv). Identify the differences between the two diagrams. (3 marks)

vi) It is required to check the ductility of clay. Suggest an experiment that will enable the determination of ductility of clay. (4 marks)

4.

a) As a metal, copper is used mainly by the electricity industry in the form of wires either bare or insulated. Normally electric wiring consists of copper wire surrounded by polyvinyl chloride (PVC). In a special type of electric wiring used in fire alarm systems, a copper wire is surrounded by solid magnesium oxide to act as an insulator, the whole wire being encased in a copper mesh covered with PVC.

i) State the electronic configuration of copper. (2 marks)

ii) Describe the bonding in copper metal and hence explain how it conducts electricity. (2 marks)

iii) What type of bonding is present in PVC? Hence explain why it can be used as an insulator. (3 marks)

iv) Discuss the properties and characteristics found in PVC and its uses other than cable covering. (3 marks)

v) Suggest a polymer, which can be used instead of PVC in cable covering. (2 marks)

vi) What type of bonding is present in magnesium oxide? Hence explain how it can act as an insulator even in fire alarm systems. (2 marks)

b)

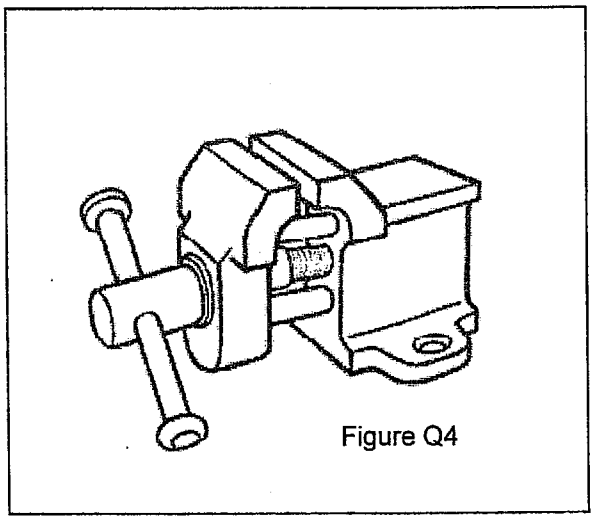

Figure Q4

Figure Q4 illustrates the well-known bench vice. The body of the bench vice is usually made of cast iron. Cast iron is a brittle material.

i) Explain why the body is made of cast iron? (2 marks)

ii) Suggest materials for the rod and the base. Explain why you selected the said materials. (1.5 marks)

5.

a) Allotropy is defined as the ability of single substance to exist in more than one physical form. Iron as an example is Body Centred Cubic (BCC) at ambient temperatures but heating up to 910^0 C leads to recrystallisation to a Face Centred Cubic structure (FCC). Further heating to 1400^0 C reverts to a BCC form. If the lattice parameter is **a** and atomic diameter is **D**,

i) Compute the number of atoms contained in BCC and FCC structures. (2 marks)

ii) Compute lattice parameter in a unit cell in terms of atomic diameter **D** for BCC and FCC structures. (2 marks)

iii) Determine the packing fractions for both BCC and FCC structures. (3 marks)

iv) Determine the density for both the structures. (2.5 marks)

b) All of the more ductile and malleable metals have FCC structures. Explain why. (2 marks)

c) Silicon Carbide is a ceramic material of simple composition and structure. Though less harder than diamond Silicon Carbide is a very hard material and hence a well known abrasive material.

i) Determine the electronic configuration of Si and C. (1 marks)

ii) Describe its structure and bonding. (2 marks)

iii) Considering the bonding in Silicon carbide, explain its high hardness. (3 marks)

6. The periodic table of elements clearly shows the periodicity of the physical and chemical properties of the elements and their compounds.

i) Discuss the difference between the periodic table developed by Mendeleev (1869) and the modern periodic table. (2 marks)

ii) Find the number of protons, neutrons and electrons in the following and determine their electronic configuration. (2 marks)

a) $^{56}_{26}Fe$ b) $^{32}_{16}S^{2-}$

iii) The atomic radius and hence the atomic volume of the elements within a period decreases as the atomic number of the elements increases. Explain why. (2 marks)

iv) List the following elements in order of increasing atomic radius: Mg, K, Ca (2 marks)

vi) Compare the lattice energies and melting points of lithium fluoride and Cesium chloride. (2 marks)

vii) The molecular compound urea $(NH_2)_2CO$ is used in fertilizers to supply nitrogen. Determine the mass of 1 mol of urea. (3.5 marks)

viii) Calculate the mass in grams of one urea molecule. (2 marks)

7.

a) A titration experiment was carried out by a student to find stoichiometry of the reaction between HCl and Na_2Co_3. Titration was performed by a 2.9929 g sample of impure Sodium Carbonate dissolved in water and titrated to a methyl orange end point with 0.4150M HCl. If 33.75 ml of the acid is used for the reaction;

i) Describe the function of an acid base indicator. (1 marks)

ii) Explain the steps, which you will carry out in performing the above titration experiment in the laboratory. (1.5 marks)

iii) Write down the equilibrium equation for the above case. (2 marks)

iv) Determine the percent by mass of the sodium carbonate in the sample. (3 marks)

v) State two errors that can occur during titration and the precautions that can be taken to reduce the errors. (2 marks)

b) The Cathode Ray Tube led to the discovery of electrons within the atom.

i) Explain how a beam of electrons can be produced in a vacuum tube and describe an arrangement by which the beam may be deflected by a magnetic field. Give an example of an electrical equipment which uses the above arrangement. (2.5 marks)

ii) In florescent lamps, the tube lights up when an electric current passes through it. Explain why the ends of fluorescent lamps glow red during starting. (2 marks)

iii) Millikin succeeded in measuring the electric charge in an electron using observations made on charged oil droplets. Describe the experimental set up used and the major conclusions reached by him. (2 marks)

iv) State the difference between the model of the atom proposed by Rutherford and the modern concept of an atom. (1.5 marks)

Perodic Table

PERIODIC TABLE OF THE ELEMENTS

1A												3A	4A	5A	6A	7A	8A
1 H 1.008	2A																2 He 4.003
3 Li 6.939	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.183
11 Na 22.99	12 Mg 24.312	3B	4B	5B	6B	7B	----------8B----------			1B	2B	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.9	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.71	29 Cu 63.546	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.8
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc [97]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.4	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.91	56 Ba 137.34	57* La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po 210	85 At 210	86 Rn 222
87 Fr 215	88 Ra 226.03	89** Ac 227.03	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [269]	109 Mt [268]	110 [271]	111 [272]	112 [277]		114 [289]		116 [289]		

*Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 145	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.5	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
**Actinides	90 Th 232.04	91 Pa 231	92 U 238.03	93 Np 237.05	94 Pu 239.05	95 Am 241.06	96 Cm 244.06	97 Bk 249.08	98 Cf 252.08	99 Es 252.08	100 Fm 257.1	101 Md 258.1	102 No 259.1	103 Lr 262.11

Gaseous at room temperature
Liquid at room temperature
Gallium melts at 29.78 deg. C.
Synthetic elements
All other elements are solid at room temperature