LEAVING CERTIFICATE EXAMINATION, 2014

ENGINEERING – MATERIALS AND TECHNOLOGY

(Higher level – 300 marks)

THURSDAY, 5 JUNE MORNING 9:30 – 12:30
INSTRUCTIONS

1. Answer Question 1, Section A and Section B, and FOUR other questions.

2. All answers must be written in ink on the answer book supplied.

3. Diagrams should be drawn in pencil.

4. Graph paper is supplied for graphs, as required.

5. Please label and number carefully each question attempted.
Question 1. (100 marks)

Section A – 50 marks

Give brief answers to any ten of the following:

(a) Identify two hazards associated with using adhesives on plastics.

(b) The occasional table shown opposite was designed by the celebrated Irish designer Eileen Gray. Describe two design features associated with this table.

(c) Discuss the advantages of upcycling the inner tubes of tyres to produce designer bags.

(d) Outline two reasons for the use of tubular steel in the roof structure of modern sport arenas, such as Croke Park in Dublin and Thomond Park in Limerick.

(e) The screen of the portable computer tablet shown is made from glass. Outline one advantage and one disadvantage of using glass screens.

(f) Describe the importance of allotropy in carbon steel.

(g) Differentiate between amorphous and crystalline structures.

(h) Discuss the contribution that any one of the following has made to technology:
   (i) Jack Kilby  (ii) Marie Curie  (iii) John Dunlop.

(i) A prosthetic hand is shown opposite. Outline two reasons why research is important at the design stage of prosthetic devices.

(j) Describe two important properties of a material which is suitable for the manufacture of a prosthetic hand.

(k) Discuss two advantages of using pneumatics in industry.

(l) Explain the association between conductivity and the metallic bond.

(m) Nylon inserts are used in the steering column mounting of a car, as shown. Outline two reasons for using nylon in the steering column mounting.
Section B – 50 marks
Answer all of the following:

(n) Nuclear power plants provide some of the energy in many modern industrialised economies. Discuss this energy source with reference to:
   - Efficiency
   - Environmental impact.

(o) A simplified diagram of a nuclear power plant is shown.
   (i) Identify the parts labelled A, B and C.
   (ii) Describe the principles of operation of a nuclear power plant.

(p) Describe briefly the nuclear fission process with reference to: the reactor fuel, the enrichment process and the exponential increase.

(q) Chernobyl in 1986 and Fukushima Daiichi in 2011 are widely considered to have been the worst nuclear power plant accidents in history. Outline three consequences of nuclear accidents.

(r) Safety is a primary concern in the design, construction and operation of any modern nuclear power plant. Describe how any two of the following contribute to overall safety:
   (i) Modern safety regulations;
   (ii) Containment building;
   (iii) Back-up power supply.
Question 2. (50 marks)

(a) Following an analysis of a road accident black-spot, it has been decided to reinforce the crash barrier shown with an additional post. The post is to be centered between the posts X and Y shown opposite.

Tensile test results on three metals A, B and C, which may be suitable for the additional post, are shown.

(i) Analyse the main properties of metals A, B and C.

(ii) Select the most suitable metal from A, B and C for the additional post and outline two reasons for your selection.

(b) The results shown below were obtained from a tensile test on a non-ferrous alloy.

<table>
<thead>
<tr>
<th>Stress (N/mm$^2$)</th>
<th>45</th>
<th>90</th>
<th>135</th>
<th>200</th>
<th>275</th>
<th>308</th>
<th>335</th>
<th>345</th>
<th>340</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strain ($\times 1000$)</td>
<td>0.50</td>
<td>1.00</td>
<td>1.50</td>
<td>2.25</td>
<td>3.25</td>
<td>4.00</td>
<td>5.00</td>
<td>6.50</td>
<td>7.50</td>
</tr>
</tbody>
</table>

Using the graph paper supplied, plot the Stress-Strain diagram for the alloy and determine:

(i) Young’s modulus of elasticity;

(ii) The 0.1% proof stress.

(c) (i) A sample of a weld is shown. Evaluate the quality of this weld.

(ii) Describe, with the aid of a diagram, a non-destructive test suitable for testing weld quality.
(a) Answer any two of the following:

(i) Describe the heat treatment process of normalising.
(ii) Distinguish between eutectic point and eutectoid point.
(iii) Explain the term re-crystallisation.
(iv) Outline the effects of adding any two elements to iron and carbon in the production of alloy steels.

(b) A simplified portion of the iron-carbon equilibrium diagram is shown.

(i) Identify the regions A and B.
(ii) Compare the main properties of the steel at X, which has 0.3% carbon, and the steel at Y, which has 1.5% carbon.

(c) The tip of the height gauge shown is to be made from carbon steel. A cast iron surface plate is also shown.

(i) Compare the different heat treatment requirements for the carbon steel tip and the cast iron surface plate.
(ii) Describe, with the aid of a diagram, a suitable heat treatment process for the surface plate.
Question 4. (50 marks)

(a) (i) Describe any two factors that should be considered during the design of a weather vane in order to prevent corrosion.

(ii) Describe any two suitable methods that could be used to protect the metal weather vane shown, from the corrosive effects of the environment.

(b) The table shows the solidification temperatures for various alloys of Cadmium and Zinc.

<table>
<thead>
<tr>
<th>% of Zinc in alloy</th>
<th>0</th>
<th>10</th>
<th>14</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of solidification (°C)</td>
<td>321</td>
<td>290</td>
<td>266</td>
<td>275</td>
<td>293</td>
<td>310</td>
<td>328</td>
<td>345</td>
<td>362</td>
<td>380</td>
<td>401</td>
<td>419</td>
</tr>
<tr>
<td>End of solidification (°C)</td>
<td>266</td>
<td>266</td>
<td>266</td>
<td>266</td>
<td>266</td>
<td>266</td>
<td>266</td>
<td>266</td>
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<td>266</td>
</tr>
</tbody>
</table>

(i) Using the graph paper supplied, draw the thermal equilibrium diagram according to the given data.

(ii) Label and describe the main features of the diagram.

(iii) State the melting point of Cadmium and the melting point of Zinc.

(c) (i) Distinguish clearly between a substitutional solid solution and an interstitial solid solution.

(ii) Describe one effect of the movement of the line defect shown below.
Question 5. (50 marks)

(a) With reference to manual metal arc welding, answer any three of the following:

(i) Name the components A, B and C in the welding circuit shown above.
(ii) Describe the operation of each of the components A, B and C in this welding circuit.
(iii) Outline three safety precautions to be observed during manual metal arc welding.
(iv) Discuss two advantages of multi-run welds.

(b) High performance car exhaust pipes are often manufactured in stainless steel and joined by welding.

(i) Name a suitable welding process for an exhaust pipe.
(ii) Describe, with the aid of a suitable diagram, the main features of this welding process.

(c) Describe each of the following:

(i) The composition and uses for each of the three principal flames in oxy-acetylene welding.
(ii) Any three methods of joint protection when welding.

OR

(c) (i) Outline two reasons why robotic welding is suitable for large scale industrial production.
(ii) Identify two methods to control the movement of industrial robots.
Question 6. (50 marks)

(a) The casing for the games controller shown is to be manufactured in a large scale production run, using a thermoplastic material.

   (i) Select a manufacturing process suitable for making the casing and state one reason why the manufacturing process selected is suitable.

   (ii) Describe, with the aid of a suitable diagram, the operation of this process.

(b) Describe how polymer properties may be enhanced by any three of the following:

   (i) Plasticisers;
   (ii) Stabilisers;
   (iii) Glass or carbon fibre;
   (iv) Lamination.

(c) A thermosetting plastic is used in the manufacture of the electric kettle shown. Most thermosetting plastics are produced by condensation polymerisation.

   (i) Outline two reasons for choosing thermosetting plastics for this application.

   (ii) Describe the process of condensation polymerisation.
Question 7. (50 marks)

(a) Answer any three of the following:

(i) Identify three safety features integrated into a milling machine.
(ii) Describe the formation of a built-up edge on a cutting tool.
(iii) Outline the purpose of dressing a grinding wheel.
(iv) Differentiate between forming and generating when machining.
(v) Discuss two reasons why inaccuracies may occur during precision measurement.

(b) Many factors have to be considered for effective metal cutting and machinability.

(i) Describe two factors that influence metal machinability.
(ii) Outline three functions of cutting fluids in effective metal cutting.

(c) Answer part (i) or part (ii):

(i) Describe, with the aid of suitable diagrams, each of the following:
   • a single point cutting tool
   • a multi-point cutting tool
   • an abrasive cutting tool.

(ii) Describe how carbide cutting tools are manufactured and state two advantages of using carbide cutting tools.

OR

(c) Describe each of the following with reference to CNC machining:

(i) The advantages of CNC machining in industrial engineering.
(ii) Two safety features integrated into CNC software.
(iii) The role of simulation in CNC machining.
Question 8.  

(a) Describe how the linkage system controls the throttle lever of the carburettor, as shown opposite.

(b) Describe any three of the following:
   (i) The differences in operation between a single-acting cylinder and a double-acting cylinder in pneumatic control.
   (ii) The operation and application of a rack and pinion system.
   (iii) One application of reciprocating motion.
   (iv) A toggle mechanism.
   (v) The function of idler gears.

(c) It is proposed to design a model based on the DeLorean DMC-12 sports car shown. Describe, with the aid of a suitable diagram, a mechanism that would allow the **gull-wing doors** in the model to open and close.

OR

(c) With reference to the timer circuit shown below:
   (i) Name the components that determine the timing of the circuit.
   (ii) Outline two advantages of using an integrated circuit (IC).