Summer Examination 2016

ENG100616N

Module Title: Mechanical Principles
Level: Four
Time Allowed: Two hours

Instructions to students:

- Enter your student number **not** your name on all answer books.
- Answer **four** out of **five** questions. Note you will only be marked on your first four questions answered.
- All questions are equally weighted. Where a question has more than one part the division of marks is stated.
- Begin each question on a separate page; label each page clearly with the number of the question you are answering.
- Neither books nor notes may be taken into the examination.
- The use of a non-programmable calculator is permitted.
- Formula booklet and graph paper will be provided.

<table>
<thead>
<tr>
<th>No. of Pages</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Questions</td>
<td>5</td>
</tr>
</tbody>
</table>
Answer four out of five questions.

1. a. With the aid of simple diagrams explain the terms:
   i. tensile force,
   ii. compressive force,
   iii. shear force.  
   (3 marks)

b. Define the following terms:
   i. stress,
   ii. strain,
   iii. Young’s Modulus of Elasticity.  
   (3 marks)

c. A mild steel specimen of cross-sectional area 250 mm$^2$ and gauge length 100 mm was subjected to a tensile test and the following data obtained:

   Load at Yield Point = 80 kN
   Maximum load on specimen = 120 kN
   Final cross-sectional area of waist at fracture = 90 mm$^2$
   Final gauge length at fracture = 135 mm

   Determine:
   i. the Yield Stress,
   ii. the Tensile Strength,
   iii. the percentage elongation,
   iv. the percentage reduction in area.  
   (8 marks)

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*Question 1 continues overleaf*
d. A component is machined from a length of solid square bar to form a circular shaft of diameter 30 mm with a square flange of side 30 mm at one end, see Fig Q1d. Determine the stress in each of the sections if an axial compressive load of 50 kN is applied to the component.

![Fig Q1d](image)

(4 marks)

e. A simple riveted lap joint connecting two plates is formed from four rivets arranged in two rows, see Fig Q1e. If the rivet diameter is 6 mm and the maximum shear stress (i.e. the shear strength) of the rivet material is 300 N/mm² determine the maximum safe working load [F] for the joint if a Factor of Safety of 5 is used.

![Fig Q1e](image)

(7 marks)

(Total: 25 marks)

End of Question 1
Question 2 follows overleaf
2. A shaft 60 mm diameter and 0.8 m long is subjected to a torque of 1400 Nm. Calculate the maximum shear stress and the angle of twist given that $G = 80$ GPa.

State 3 assumptions made in the theory of torsion of circular shafts.

25 marks

3. String is wound around the central drum of a wheel of mass 0.6 kg as illustrated in Fig Q3. The drum is of radius 0.012 m and the wheel has a radius of gyration of 0.025 m. As the wheel is released it descends and rotates. Calculate the linear and angular velocity of the wheel after it falls 0.8 m.

![Fig Q3](image)

25 marks
4. A pipe 120 mm bore diameter carries oil of density 800 kg/m$^3$ at a rate of 5 kg/s with negligible frictional losses. The pipe reduces to 80mm bore diameter and rises 140m in altitude where the pressure at this point is atmospheric (zero gauge).

   a. Determine the volume flow rate. (4 marks)

   b. Determine the velocity at each section. (6 marks)

   c. Determine the pressure at the lower end. (10 marks)

   d. Explain briefly the application of the First Law of Thermodynamics to the steady flow of a fluid. (5 marks)

   (Total: 25 marks)

5. Three masses A, B and C are placed on a balanced disc as shown in Fig Q5 at radii of 140 mm, 120 mm and 100 mm respectively. The masses are 2 kg, 1.0 kg and 1.4 kg respectively. Find the 4th mass which should be added at a radius of 80 mm in order to statically balance the system.

Fig Q5

(Total: 25 marks)