S5 Design and Applied Technology Practice Paper (Set 1): Structures, Materials, Drives, Electronics and Design Practice

S5 Design and Applied Technology | Time: 75 minutes | Total: 100 marks | 24 questions

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Section A: Structures and Moments (17 marks)

Answer all parts. Show your working and state the units.

1. (a) A 4.0 m horizontal beam is hinged at its left end. A 600 N load hangs 2.5 m from the left end, and the right end rests on a roller. Find the right support force and the left reaction. (4 marks)

2. (b) A steel rod of 12 mm diameter carries a tensile load of 15 kN. Calculate the tensile stress in MPa. (4 marks)

3. (c) The Young modulus of the steel is 200 GPa. Find the strain and the extension of a 2.0 m length of the rod in mm. (5 marks)

4. (d) State three ways to increase the bending strength of a beam and explain each in one sentence. (4 marks)

Section B: Materials and Manufacture (17 marks)

Show formulae and units in your calculations.

5. (a) An aluminium plate measures 1.2 m x 0.8 m x 3 mm. The density of aluminium is 2700 kg/m^3. Find the volume in m^3 and the mass in kg. (5 marks)

6. (b) The aluminium costs $38 per kg and 20% is allowed for waste. Find the material cost of the plate. (4 marks)

7. (c) Explain the purpose of annealing, quenching and tempering of steel, and why tempering usually follows quenching. (4 marks)

8. (d) Compare welding with mechanical fastening such as screws or rivets: give one advantage and one limitation of each. (4 marks)

Section C: Gear and Belt Drives (17 marks)

Assume 100% efficiency unless stated otherwise.

9. (a) In a gear pair the driver has 24 teeth and the driven gear 72 teeth. Input speed is 300 rpm at 8 N m. Find the output speed and torque. (5 marks)

10. (b) A belt drive has a 80 mm driver and a 240 mm driven pulley at 900 rpm input. Find the output speed ignoring slip, then the actual speed with 5% slip. (5 marks)

11. (c) A lead screw has a lead of 4 mm. How many turns are needed to move the table 60 mm? (3 marks)

12. (d) Describe one use of a cam mechanism in an automated machine and explain how rotary motion becomes reciprocating motion. (4 marks)

Section D: Electronics and Control (17 marks)

Show formulae and units in your calculations.

13. (a) In a voltage divider R1 = 4.7 k ohm and R2 = 10 k ohm across 12 V, the output is taken across R2. Find the output voltage. (4 marks)

14. (b) An LED with a 2.0 V forward drop runs at 20 mA from a 5 V supply. Find the series resistor and state the power rating to choose. (5 marks)

15. (c) An RC circuit has R = 10 k ohm and C = 470 microfarad. Find the time constant and the time to charge to about 95%. (4 marks)

16. (d) Using a temperature sensor, a comparator and a relay, describe the sequence from rising temperature to the cooling fan starting. (4 marks)

Section E: Drawings, Scale and Tolerance (16 marks)

Answer all parts.

17. (a) On a drawing at 1:50 a wall measures 84 mm. Find its actual length in metres. (4 marks)

18. (b) In third angle projection, which views are normally used and how are they arranged on the sheet? (4 marks)

19. (c) A shaft is dimensioned 30 plus or minus 0.2 mm. Find the maximum and minimum limits, and the worst-case clearance or interference with a hole of 30 plus or minus 0.1 mm. (4 marks)

20. (d) Compare isometric and oblique projection for showing a solid, giving one suitable use for each. (4 marks)

Section F: Design, Sustainability and Intellectual Property (16 marks)

Answer in full sentences.

21. (a) State three principles of sustainable design and give a product example for each. (4 marks)

22. (b) What is a product life cycle assessment and which stages does it usually cover? (4 marks)

23. (c) How do a registered design and a standard patent differ in what they protect? Give one example for each. (4 marks)

24. (d) Using ergonomic principles, state two factors to consider when designing a hand tool handle and the consequence of ignoring them. (4 marks)

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