S4 Design and Applied Technology Practice Paper: Design Process and Human-centred Design, Structures and Moments, Mechanisms and Transmission, Electronics and Control, Materials and Manufacturing, Systems and Sustainable Development

S4 | Design and Applied Technology | Time: 75 minutes | Total: 100 marks | 24 questions

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Part A: Design Process and Human-centred Design (16 marks)

Show the formula and steps for calculations; answer explanation questions in numbered points.

1. A design project has 40 working days in total, of which 25 percent is for research and 30 percent for sketching. Find the total number of working days used for research and sketching, and the number of days remaining. [4]

2. An ergonomics guideline recommends a desk height of 720 mm with a tolerance of plus or minus 25 mm. Find the upper and lower limits of the acceptable height and the width of the acceptable range. [4]

3. A company registers 8 designs. Each registration costs 1,200 dollars and a handling fee of 3,500 dollars is charged once. Find the total cost and state one benefit of registering a design for a designer. [4]

4. List four main stages of the modern design process and give one example of how user needs can be collected. [4]

Part B: Structures and Moments (16 marks)

Show the formula, substitute the values and state the unit.

5. A force of 60 N acts perpendicularly at 0.35 m from a pivot. Find the moment of the force about the pivot. [4]

6. A timber strut has a cross-section of 12 mm by 20 mm and carries an axial tensile force of 4,800 N. Find the cross-sectional area and the tensile stress in N/mm2. [4]

7. The ultimate strength of a steel is 320 MPa and the design working stress is 80 MPa. Find the factor of safety and explain why it must be greater than 1. [4]

8. State three ways of increasing the bending resistance of a beam and briefly explain each. [4]

Part C: Mechanisms and Transmission (17 marks)

Give ratios in simplest form and state speeds in rpm.

9. A pair of meshing gears has a driver of 18 teeth and a driven gear of 54 teeth. The driver turns at 900 rpm. Find the speed ratio and the speed of the driven gear. [4]

10. In a belt drive the driving pulley has a diameter of 80 mm and the driven pulley 200 mm. The driving pulley turns at 1000 rpm. Find the velocity ratio and the driven speed. [4]

11. A gearbox receives 500 W and delivers 425 W. Find the transmission efficiency and the power lost. [4]

12. A single-start worm drives a worm wheel with 40 teeth. The worm turns 20 revolutions. Find the number of revolutions of the wheel and state two advantages of this drive in high reduction applications. [5]

Part D: Electronics and Control (17 marks)

Current may be given in A or mA; give voltages to two decimal places.

13. A 240 ohm resistor is connected across a 12 V supply. Find the current in mA. [4]

14. Three resistors of 120 ohm, 180 ohm and 200 ohm are connected in series across 10 V. Find the total resistance and the current. [4]

15. An LED operates at 3.3 V and 20 mA. Find the power of one LED and the total power of 5 such LEDs in mW. [4]

16. In a potential divider R1 = 4.7 k ohm is between the supply and the output and R2 = 10 k ohm between the output and earth, with a 5 V supply. Find the output voltage to two decimal places and state how the output changes if R2 is replaced by a light-dependent resistor as light increases. [5]

Part E: Materials and Manufacturing (17 marks)

Give density in g/cm3 and state the unit of every cost.

17. An aluminium plate measures 200 mm by 300 mm by 2 mm. The density of aluminium is 2.7 g/cm3. Find the volume in cm3 and the mass in grams. [4]

18. A part costs 45 dollars in material and 18 dollars in labour, and tooling is apportioned at 7 dollars per unit. If the selling price is 98 dollars, find the unit cost, the unit profit and the profit margin as a percentage of the selling price to one decimal place. [4]

19. A shaft has a nominal diameter of 25.00 mm with a tolerance of plus or minus 0.05 mm. Find the upper and lower limits and the tolerance range, and decide whether a measured diameter of 24.94 mm is acceptable, giving a reason. [4]

20. Explain how jigs and fixtures, standardisation of parts and quality control each reduce the unit cost of batch production, one point each. [5]

Part F: Systems and Sustainable Development (17 marks)

Give efficiency as a percentage and state the unit of every amount of energy and cost.

21. A machine takes 2.4 kW and delivers 1.8 kW. Find its efficiency and the power lost in watts. [4]

22. An appliance uses 180 kWh a year, has a service life of 8 years and electricity costs 1.2 dollars per kWh. Find the total energy used and the total electricity cost. [4]

23. An off-grid system needs 1.2 kWh a day. The panels have an area of 2 m2 and an efficiency of 20 percent, and receive 1,000 W/m2 for 4 effective hours a day. Find the daily generation and decide whether it meets the demand. [4]

24. For one domestic appliance, state two benefits of automatic control and two benefits of sustainable design. [5]
