# S6 Design and Applied Technology Practice Paper: Structures and Mechanics, Gears and Power Transmission, Electronics and Control, Materials and Manufacturing, Energy Systems, Design Analysis and Ergonomics (100 marks)

Level: S6 | Subject: Design and Applied Technology | 75 minutes | 100 marks | 24 questions | question paper

## Part 1 Structures and Mechanics (16 marks)

**Show all formulae, substitutions and calculation steps.**

| # | Question | Marks |
|---|---|---|
| 1 | A steel rod 2.0 m long has a cross-sectional area of 250 mm2 and carries a 50 kN tensile load. Find the tensile stress in MPa. | 4 |
| 2 | The same rod extends by 1.2 mm. Find the strain (decimal) and the Young modulus in GPa to 1 decimal place. | 4 |
| 3 | A rectangular beam is 50 mm wide and 100 mm deep. Find its second moment of area in mm4 to 3 significant figures, then the bending stress in MPa at 50 mm from the neutral axis when the maximum bending moment is 2.5 kNm. | 4 |
| 4 | The steel has an ultimate strength of 480 MPa and a working stress of 160 MPa. Find the factor of safety; if the working load is doubled, find the new factor and say whether it meets the usual requirement of at least 2. | 4 |

## Part 2 Gears and Power Transmission (16 marks)

**Give units for every power and efficiency answer and state significant figures.**

| # | Question | Marks |
|---|---|---|
| 5 | Gear A has 20 teeth and runs at 900 rpm, driving gear B with 60 teeth. Find the gear ratio and the speed of gear B in rpm. | 4 |
| 6 | A motor delivers 12 Nm at 1450 rpm. Find its output power in watts (whole number) and in kW to 3 decimal places. | 4 |
| 7 | The motor drives a load through a gearbox of 85% efficiency. Find the gearbox output power in watts and the power lost in watts. | 4 |
| 8 | A screw jack has a 5 mm lead, an input torque of 8 Nm and 40% efficiency. Find the axial load it can raise in newtons (whole number) and in kN to 2 decimal places. | 4 |

## Part 3 Electronics and Control Circuits (17 marks)

**For electronics questions, describe the circuit and state the formulae used.**

| # | Question | Marks |
|---|---|---|
| 9 | A 12 V supply is connected to 4 kohm and 8 kohm resistors in series. Find the current in mA and the voltage across the 8 kohm resistor in V. | 4 |
| 10 | A potential divider uses 10 kohm and 22 kohm resistors across a 12 V supply with no load. Find the output voltage across the 22 kohm resistor to 2 decimal places. | 4 |

| | | |
|---|---|---|
| 11 | A 47 kohm resistor and a 100 microfarad capacitor are in series across 12 V. Find the time constant in seconds (1 decimal place), the time to reach 63.2% of full charge, and the 5 time-constant time treated as fully charged. | 4 |
| 12 | An inverting op-amp has a 100 kohm feedback resistor, a 10 kohm input resistor and ±12 V rails. Find the voltage gain, the output for a 0.25 V input, and say whether the output saturates. | 5 |

## Part 4 Materials and Manufacturing (17 marks)

**Use the units given in each material and machining question.**

| # | Question | Marks |
|---|---|---|
| 13 | An aluminium plate measures 200 x 100 x 20 mm and aluminium has a density of 2700 kg/m3. Find the volume in m3 and the mass in kg to 2 decimal places. | 4 |
| 14 | A 25 m steel rail has a coefficient of linear expansion of 12e-6 per degree and sees a 40 degree temperature change. Find the change in length in mm (whole number) and explain why expansion gaps are needed. | 4 |
| 15 | A milling cutter is 50 mm in diameter and runs at 1200 rpm. Find the cutting speed in m/min to 1 decimal place. | 4 |
| 16 | The same cut uses 0.05 mm per tooth with 4 teeth. Find the feed rate in mm/min and the time to mill a 480 mm long workpiece in minutes to 1 decimal place. | 5 |

## Part 5 Energy System Efficiency (17 marks)

**Separate input, output and losses in every energy answer.**

| # | Question | Marks |
|---|---|---|
| 17 | A 1.6 m2 PV panel has 20% efficiency under 800 W/m2 irradiance. Find its instantaneous output in W. | 4 |
| 18 | The panel gets 5 effective sun hours a day and the home uses 3.2 kWh a day. Find the daily generation in kWh and the percentage of demand covered (whole number). | 4 |
| 19 | A 12 V 100 Ah battery is limited to 80% depth of discharge. Find the usable energy in kWh (2 decimal places) and how long it runs a 200 W load in hours (1 decimal place). | 4 |
| 20 | The PV system has 90% charging efficiency and a 92% efficient inverter. Find the overall system efficiency as a percentage (2 decimal places) and the AC output in W (whole number). | 5 |

## Part 6 Design Analysis and Ergonomics (17 marks)

**State your assumptions and rounding for costing and ergonomics answers.**

| # | Question | Marks |
|---|---|---|
| 21 | A part has a net mass of 0.35 kg, a scrap rate of 15% and material costing $48 per kg. Find the material consumed per part in kg (4 decimal places) and the material cost per part to 2 decimal places. | 4 |
| 22 | Tooling costs $120,000 for a batch of 5000 parts. Find the tooling cost per part and the total cost per part to 2 decimal places. | 4 |
| 23 | The selling price is $65 per part. Find the profit per part, total profit and contribution margin as a percentage to 1 decimal place. | 4 |
| 24 | User height for a product is normal with a mean of 170 cm and standard deviation of 6 cm. Find the 5th and 95th percentile heights in cm (1 decimal place, using z = ±1.645) and explain | 5 |

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|---|---|---|
| | why the adjustable range is set this way. | |