S5 Design and Applied Technology Practice Paper: Mechanical Advantage and Efficiency, Gear and Belt Drives, Stress and Strain, Beam Moments, Fluid Pressure and Circuits (100 marks)

Level: S5 | Subject: Design and Applied Technology | 75 minutes | 100 marks | 24 questions | question paper

Section A: Mechanical Advantage and Efficiency (17 marks)

Each question is worth 4-5 marks; state the formula and units.

#	Question	Marks
1	A simple hoist lifts a load of 1200 N with an effort of 250 N. The load rises 0.80 m while the effort moves 4.80 m. (a) Find the mechanical advantage (MA). (b) Find the velocity ratio (VR). (c) Find the efficiency.	4
2	A ramp is 3.00 m long and 0.90 m high. A load of 600 N is pulled up the ramp with an effort of 220 N. Find the velocity ratio, mechanical advantage and efficiency.	4
3	A screw jack has a handle 0.30 m long and a pitch of 4.0 mm. An effort of 90 N raises a load of 15000 N. Find the velocity ratio, mechanical advantage and efficiency.	4
4	A pulley system has 4 supporting rope sections. An effort of 300 N lifts a load of 1020 N, and the effort moves 2.00 m while the load rises 0.50 m. (a) Find MA and VR. (b) Find the efficiency. (c) Find the work input and the useful work output.	5

Section B: Gear and Belt Drives (17 marks)

Each question is worth 4-5 marks; give speed in rpm.

#	Question	Marks
5	A motor runs at 1440 rpm and its 20-tooth gear drives a 60-tooth gear. Find the output speed and the torque multiplication.	4
6	Pulley A is 80 mm in diameter and runs at 900 rpm; it drives pulley B of 240 mm diameter by belt with no slip. (a) Find the speed of B. (b) Find the belt linear speed.	4
7	A gear train has a 24-tooth input gear driving a 48-tooth intermediate gear, which is on the same shaft as an 18-tooth output gear. Input speed is 600 rpm. (a) Find the output speed. (b) Find the overall ratio (output / input).	4
8	A gearbox takes 1500 W input and delivers 1320 W output. (a) Find the efficiency. (b) Find the power loss. (c) If all the loss becomes heat, find the heat generated in 5 minutes in kJ.	5

Section C: Stress, Strain and Young Modulus (17 marks)

Each question is worth 4-5 marks; give stress in MPa and show the area calculation.

#	Question	Marks
9	A steel rod of 10 mm diameter carries a tensile force of 15 kN. Find the tensile stress in MPa (3 significant figures).	4
10	The same steel rod is 2.00 m long and stretches 1.2 mm under the load. Find the strain and the Young modulus of the steel in GPa.	4
11	An aluminium wire of 2.0 mm diameter and 1.50 m length has a Young modulus of 70 GPa and carries 500 N. Find the stress, the strain and the extension in mm.	4

12	A steel cable of 8.0 mm diameter has a permissible stress of 250 MPa and a safety factor of 2.0. (a) Find the breaking load. (b) Find the maximum safe working load. Why is a safety factor used?	5

Section D: Moments, Beams and Centre of Gravity (17 marks)

Each question is worth 4-5 marks; give moments in N m.

#	Question	Marks
13	A spanner is 0.25 m long and a force of 120 N is applied at its end. Find the moment when the force is perpendicular to the handle, and when it acts at 60 degrees to the handle.	4
14	A student of 40 kg sits 1.20 m to the left of a seesaw pivot. What mass must sit 0.80 m to the right to balance it? (Ignore the plank weight.)	4
15	A simply supported beam is 6.0 m long with a 900 N point load 2.0 m from the left end. Find the two support reactions and show that their sum equals the load.	5
16	A uniform rod is 2.00 m long and weighs 200 N; a 300 N weight hangs from one end. Find the distance of the combined centre of gravity from that end.	4

Section E: Fluid Pressure and Hydraulics (16 marks)

Each question is worth 4 marks; take g = 9.81 m/s2 and give pressure in kPa.

#	Question	Marks
17	What is the pressure at 12 m depth in a water tank (density 1000 kg/m3, g = 9.81 m/s2)? Why does the pressure not depend on the shape of the tank?	4
18	A pump delivers 0.80 m3/min of water through a 15 m lift. Find its useful output power in kW (density 1000 kg/m3).	4
19	In a hydraulic jack the small piston is 20 mm in diameter with an applied force of 150 N; the large piston is 100 mm in diameter. Find the force it can raise and state the principle used.	4
20	A cylinder has a gauge pressure of 600 kPa and a piston of 50 mm diameter. Find the piston force, and the work done per 120 mm stroke.	4

Section F: Circuits and Power (16 marks)

Each question is worth 4 marks; state the Ohm law and power equations used.

#	Question	Marks
21	A 12 V supply is connected to a 220 ohm and a 330 ohm resistor in series. (a) Find the current in mA. (b) Find the voltage across each resistor.	4
22	A 24 V supply is connected across 120 ohm and 180 ohm in parallel. Find the equivalent resistance, the total current and each branch current.	4
23	An electric kettle is rated 2000 W at 220 V and is used for 15 minutes. (a) Find the current and the element resistance. (b) Find the energy used in kWh. (c) Find the cost at 1.20 dollars per kWh.	4
24	A potential divider has a 4.7 kohm and a 2.2 kohm resistor in series across 12 V, with the output taken across the 2.2 kohm resistor. Find the output voltage and suggest how to obtain about 5 V.	4