S5 Design and Applied Technology Practice Paper (Set 2)

Senior Secondary Design and Applied Technology

S5 Design and Applied Technology Set 2: 24 parts, 100 marks, 60 min on gear ratio, lever efficiency, tensile stress, power cost, solar efficiency and break-even.

Question 1: Gear Train and Output Speed

A gearbox drives a 48-tooth output gear from a 12-tooth input gear. The motor runs at 1200 rpm with an input torque of 0.8 N m and the transmission efficiency is 90%.

#	Question
1	Calculate the gear ratio and the output speed of the driven gear (1 decimal place).
2	Ignoring losses, calculate the ideal output torque; then find the actual output torque at 90% efficiency.
3	Calculate the input power of the motor and the output power of the gearbox in W (2 decimal places).
4	If the driven gear is replaced by a 36-tooth gear, find the new ratio and output speed, and state how the torque changes.

Question 2: Moments, Levers and Efficiency

A crowbar lifts a 240 N load 0.30 m from the fulcrum; the effort is applied 1.20 m from the fulcrum. The lever efficiency is 80% and the load rises 0.15 m.

#	Question
5	Calculate the ideal effort (friction ignored) and the mechanical advantage.
6	Allowing for 80% efficiency, find the actual effort required.
7	Calculate the useful output work, the distance moved by the effort, and the input work.
8	Verify the efficiency from the input and output work, and explain where the remaining energy goes.

Question 3: Tensile Stress, Strain and Safety Factor

A steel tie rod of diameter 12 mm and length 1.5 m carries a tensile force of 9 kN. The steel has a yield strength of 250 MPa and Young modulus of 200 GPa.

#	Question
9	Calculate the cross-sectional area (2 decimal places) and the tensile stress in MPa.
10	Using that stress, calculate the safety factor (2 decimal places).
11	Calculate the strain and the extension in mm (2 decimal places).
12	If the force rises to 18 kN, recalculate the stress and safety factor and judge whether it is still safe.

Question 4: Electrical Power, Resistance and Energy Cost

A 2000 W kettle rated 220-240 V boils water in 6 minutes when supplied at 230 V. Electricity costs 1.20 HKD per kWh.

#	Question
13	Calculate the current drawn at 230 V (2 decimal places).
14	Calculate the resistance of the heating element (2 decimal places).
15	Calculate the energy used per boil in kWh and the cost.
16	Calculate the total energy and cost for one boil a day over 30 days; if the supply drops to 220 V with unchanged resistance, find the new power and current.

Question 5: Solar Panel Efficiency and Payback

A 1.6 m x 1.0 m solar panel has 18% efficiency. The site receives an average irradiance of 850 W/m2 and 4.5 peak sun hours per day. The installed system costs 6,000 HKD.

#	Question
17	Calculate the panel area and the solar power incident on it.
18	Using 18% efficiency, calculate the electrical output power.
19	Calculate the daily and annual energy output in kWh, and the yearly saving at 1.20 HKD per kWh.
20	Calculate the simple payback period in years (1 decimal place) and state two factors that would shorten it.

Question 6: Material Usage, Cost and Break-even

A 2440 mm x 1220 mm metal sheet costs 480 HKD. Each part uses 0.45 m2 of sheet, 60 parts are required and the cutting wastage is 12%. Labour is 42 HKD per unit and fixed cost is 1,800 HKD.

#	Question
21	Calculate the area of one sheet and the material cost per square metre (area to 4 decimal places).
22	Calculate the net material for 60 parts, the requirement including 12% wastage, and the minimum number of sheets to buy.
23	Calculate the total material cost and the material cost per part.
24	If the selling price is 190 HKD per unit, find the contribution per unit and the break-even quantity against fixed cost.