S5 DAT Practice Paper I Drawing scale, tolerances, RC circuits, cooling and 3D printing costs

S5 DAT I Time allowed: 75 minutes I Total: 100 marks I 24 questions

Part A Projection drawing, scale and sheet capacity

Question 1 (16 marks)

1. A part 2 400 mm long is drawn at a scale of 1:20. Find its length on the drawing in mm. (4 marks)

> **Answer:** Length on drawing = 2400 / 20 = 120 mm.

2. A plan is drawn at 1:50 and the area on paper is 84 cm2. Find the actual area in m2. (5 marks)

> **Answer:** The area ratio is 50 squared = 2500, so actual area = 84 x 2500 = 210 000 cm2 = 21 m2.

3. The usable drawing area is 400 mm by 280 mm at a scale of 1:10. Find the largest diameter that can be drawn in full, in m. (4 marks)

> **Answer:** The short side of 280 mm limits it: 280 x 10 = 2800 mm, that is 2.8 m.

4. A part is drawn at 2:1 and measures 150 mm on paper with a tolerance of +/-0.4 mm marked. Find the real length and real tolerance in mm. (3 marks)

> **Answer:** Real length = 150 / 2 = 75 mm and the real tolerance is +/-0.4 / 2 = +/-0.2 mm.

Part B Tolerances, fits and fasteners

Question 2 (15 marks)

5. A hole is 24.000 to 24.021 mm and the shaft is 23.979 to 24.000 mm. Find the maximum and minimum clearance in mm and name the class of fit. (5 marks)

> **Answer:** Maximum clearance = 24.021 - 23.979 = 0.042 mm; minimum clearance = 24.000 - 24.000 = 0 mm, so this is a transition fit.

6. For the same limits, find the tolerance zone of the hole and of the shaft in mm and say whether they are equal. (4 marks)

> **Answer:** Hole tolerance = 24.021 - 24.000 = 0.021 mm and shaft tolerance = 24.000 - 23.979 = 0.021 mm, so both are equal at 0.021 mm.

7. At a basic size of 30 mm, IT7 is 21 micrometres and IT8 is 33 micrometres. Find the ratio of IT8 to IT7. (3 marks)

> **Answer:** Ratio = 33 / 21 = 1.57, so IT8 is about 1.57 times IT7.

8. In a batch of 200 parts the reject rate is 2% and each good part earns $45. Find the number of good parts and the total profit. (3 marks)

> **Answer:** Good parts = 200 x 0.98 = 196 and total profit = 196 x 45 = $8,820.

Part C RC charging and LED circuits

Question 3 (18 marks)

9. A resistor of 10 kohm is in series with a 470 microfarad capacitor. Find the time constant in seconds. (4 marks)

> **Answer:** Time constant = RC = 10 000 x 470 x 10^-6 = 4.7 s.

10. A 9 V supply charges the capacitor through the resistor. Find the capacitor voltage at one time constant and the time taken to reach it. (5 marks)

> **Answer:** At one time constant the voltage is 0.632 x 9 = 5.688 V and the time is 4.7 s.

11. Find the time for five time constants in seconds and state roughly what percentage of full charge has been reached. (4 marks)

> **Answer:** Five time constants take 5 x 4.7 = 23.5 s, by which the capacitor is about 99.3% charged and is treated as fully charged.

12. A 5 V supply drives an LED with a forward drop of 2.1 V at 20 mA. Find the series resistor in ohms and the power it dissipates in mW. (5 marks)

> **Answer:** Resistance = (5 - 2.1) / 0.02 = 145 ohm and power = 2.9 x 0.02 = 0.058 W, that is 58 mW.

Part D Capacitor energy and battery capacity

Question 4 (16 marks)

13. A 470 microfarad capacitor is charged to 9 V. Find the stored energy in mJ to three significant figures. (4 marks)

> **Answer:** Energy = 0.5 x 470 x 10^-6 x 81 = 0.019035 J, that is 19.0 mJ.

14. If the voltage is raised to 18 V, what is the stored energy in mJ, and why? (4 marks)

> **Answer:** Energy varies with the square of voltage, so doubling the voltage gives four times the energy: 19.0 x 4 = 76.1 mJ.

15. A 12 V, 2000 mAh battery is discharged at a constant 0.5 A. Find the running time in hours and the total energy in Wh. (4 marks)

> **Answer:** Running time = 2000 mAh / 500 mA = 4 h and energy = 12 x 2 = 24 Wh.

16. The same battery has a discharge efficiency of 85%. Find the usable energy in Wh and in J. (4 marks)

> **Answer:** Usable energy = 24 x 0.85 = 20.4 Wh = 20.4 x 3600 = 73,440 J.

Part E Heat sinks, thermal resistance and power

Question 5 (17 marks)

17. A component dissipates 5 W with a thermal resistance of 6 degC per W in a 30 degC environment. Find the temperature rise and the component temperature. (5 marks)

> **Answer:** Rise = 5 x 6 = 30 degC, so the component runs at 30 + 30 = 60 degC.

18. With a heat sink the thermal resistance falls to 2.5 degC per W while dissipation rises to 8 W at the same 30 degC ambient. Find the new temperature. (4 marks)

> **Answer:** Rise = 8 x 2.5 = 20 degC, so the new temperature is 30 + 20 = 50 degC.

19. If the maximum junction temperature is 85 degC, the ambient is 35 degC and the dissipation is 6 W, find the largest allowable thermal resistance in degC per W. (4 marks)

> **Answer:** Allowable resistance = (85 - 35) / 6 = 8.33 degC per W.

20. A cooling fan draws 0.15 A at 12 V while the chip dissipates 8 W. Find the fan power in W and its percentage of the chip dissipation. (4 marks)

> **Answer:** Fan power = 0.15 x 12 = 1.8 W, which is 1.8 / 8 x 100 = 22.5% of the chip power.

Part F 3D printing cost and pricing

Question 6 (18 marks)

21. A model has a volume of 12 cm3 and PLA has a density of 1.24 g/cm3. Find the mass of filament used in g. (4 marks)

> **Answer:** Mass = 12 x 1.24 = 14.88 g.

22. Filament costs $180 per kg. Find the material cost of that model in dollars to two decimals. (4 marks)

> **Answer:** Cost per gram is 180 / 1000 = $0.18, so material cost = 14.88 x 0.18 = $2.68.

23. Printing takes 2.5 hours at $12 per machine hour, plus 10% extra material for failed prints. Find the total cost to two decimals. (5 marks)

> **Answer:** Machine time = 2.5 x 12 = $30.00, material with 10% extra = 2.68 x 1.10 = $2.95, so the total is $32.95.

24. To achieve a 35% gross margin, find the selling price in dollars to two decimals. (5 marks)

> **Answer:** Selling price = 32.95 / (1 - 0.35) = $50.69.