End of Topic Test – Chapter 3: Modelling and Estimation

Answer all questions in the spaces provided.

1. **Fermi estimation: mobile phones**

   A large music festival has an attendance of 72 000 people. You want to estimate how many mobile phones are present at the festival.

   (a) (2 points) State two assumptions you would make when estimating the number of mobile phones.

   (b) (3 points) Using your assumptions, produce a Fermi estimate for the number of mobile phones at the festival.

   (c) (2 points) Explain one limitation of your estimate.

2. **Standard form and scaling**

   Light travels at approximately 3.0×10^8 m/s. A satellite is orbiting at a height of 4.2×10^7 m above the Earth's surface.

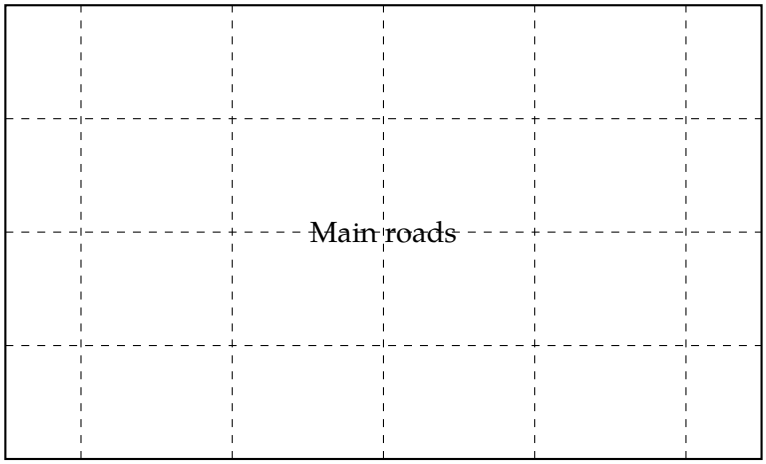
   (a) (2 points) Estimate the time (in seconds) for a radio signal to travel from the Earth to the satellite.

   (b) (3 points) A second satellite is twice as far away. Estimate the new signal travel time, explaining your scaling method.

3. **Subdividing: estimating the number of streetlights in a city**

A simplified map of a city centre is shown below.

City Centre (approx. 10 km by 6 km)



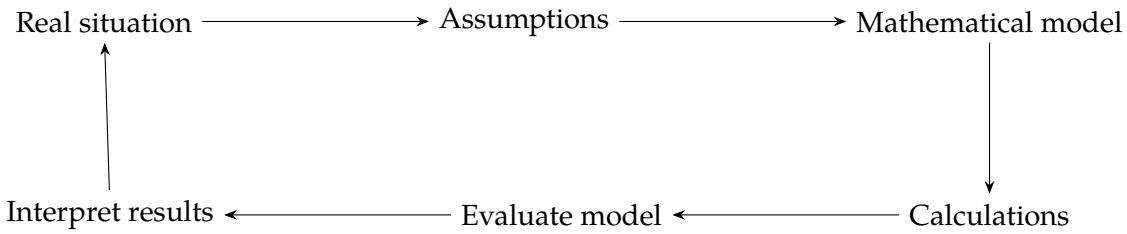
Assume streetlights are placed every 30 metres along main roads.

(a) (3 points) State two assumptions you need to make to estimate the total number of streetlights.

(b) (4 points) Use the diagram to estimate the total length of main roads and hence estimate the number of streetlights.

4. **Modelling cycle: estimating water usage**

A school has 1 200 students. You want to estimate the total volume of water used by students during a school day.



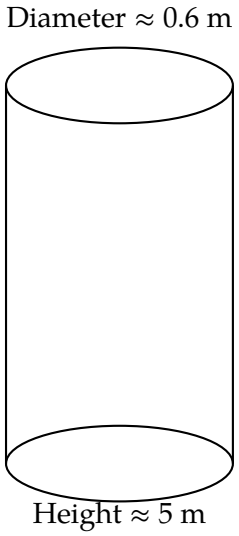
(a) (3 points) State three assumptions you would make when modelling water usage.

(b) (4 points) Produce an estimate for the total water used in one school day.

(c) (2 points) Suggest one way you could improve your model.

5. **Estimating the volume of a tree trunk**

   A tree trunk is roughly cylindrical. A diagram is shown below.



   (a) (3 points) Estimate the volume of the tree trunk in cubic metres.

   (b) (2 points) Explain one limitation of modelling the trunk as a perfect cylinder.

6. **Standard form: density of the Earth**

   The Earth has mass 6.0×10^{24} kg and volume 1.1×10^{21} m^3.

   (a) (3 points) Calculate the density of the Earth in standard form.

   (b) (2 points) Explain why standard form is useful when working with planetary data.

7. **Assumptions: estimating the number of fish in a lake**

   A lake has an estimated surface area of $2.5\,\text{km}^2$. You want to estimate the number of fish in the lake.

   (a) (3 points) State three assumptions you would need to make.

   (b) (4 points) Produce a Fermi estimate for the number of fish.

   (c) (2 points) Suggest one improvement to your model.