

Explorations in Mathematics

Due: Monday 5th February 2024

This assignment counts for 25% of the total marks for the module. This assessment covers the material in the unit **Large and Small**. You will have a much better chance of doing well if you re-read the notes carefully, and in particular try the exercises and read through the worked solutions provided, as the questions I'm asking are in a similar spirit to this material.

How to Submit this Assignment You will submit the work online, on the Moodle page for this module. You are welcome to submit handwritten work (I know how long it takes to type mathematics); this is what we expect most people will do. Handwritten work must be scanned and submitted as a pdf. You are responsible for making sure the scan quality is good enough for me to read. You can type all or part of your work if you prefer – however you do it, you'll ultimately need to submit a single pdf for the whole assignment. Detailed guidance about submission is in the Assessment section of the Moodle page. The guidance includes information about recommended apps to scan handwritten documents.

How will marks be awarded? Please look at the marking guidance in the Assessment section of the Moodle page, but the key things are to set out your work clearly, to write legibly, and to **show working** that explains your reasoning. You don't need to write a novel – you can assume I know what the notes say, so there's no need to include large chunks of exposition – but something like “by Identity 2 in the notes” helps me to understand what your reasoning is, and may allow you to get partial credit for a wrong answer. If you just write down the correct answer with no explanation then you won't get full marks. Some of the marks in your coursework will always be for the clarity of your explanations!

Late Submission College rules mean that work submitted late, unless you have a mitigating circumstances claim upheld, will be given a mark penalty. Your mark will be reduced by 10% if it is up to 7 days late. Work more than 7 days late, up to a maximum of 14 days late, will be capped at 40%. Work more than 14 days late will be given a mark of zero. For more information on the mitigating circumstances policy, please visit the Assessment section of the Moodle page for this module.

LS1: You may assume all animals are geometrically similar in this question, specified by a single representative length L (e.g. their total height, or the length of a particular bone). Their surface area therefore scales as L^2 , while their weight scales as L^3 .

- (a) Briefly explain why the power output must also scale as L^2 if animals are to avoid overheating. Can you suggest any evolutionary developments that might be expected in larger animals to avoid this? [2]
- (b) A diving mammal must carry down all oxygen required. Show that the duration of a dive is proportional to L . Would you expect deep diving mammals to be small or large? [2]
- (c) The volume of the heart scales as L^3 while the total power produced scales as L^2 . How does the pulse rate vary with L ? What would you expect to observe when measuring the pulse rate of a mouse? [3]
- (d) When jumping, an animal of mass m exerts a force T while moving upwards through a distance d . Conservation of energy implies that the total height h reached by the animal is given by

$$mgh = Td.$$

How does h vary with size L ? [3]