

due Friday 20 May, 4 pm

Complete the following problems and submit your solutions into the assignment box for your tutorial group. The assignment boxes are located on level three of the Priestley (Mathematics) Building (67), next to the elevator. The boxes are clearly labelled as **MATH1050**, and there is one for each of the tutorial groups T1-T22. Please take care to ensure your investigation is placed in the correct box.

Late investigations will be accepted only with a medical certificate or evidence of other exceptional circumstances.

Ensure that your investigation is stapled, and that your name, student number and tutorial group are clearly marked on the front page of your investigation before you hand it in. You need a cover sheet (available on the website) but do not need to include this question sheet.

Mathematics is used everyday in a wide range of situations. Your task is to investigate the practical applications of functions, differentiation and integration in terms of Blood Alcohol Content (BAC).

1.
 - a) What are the current legal BAC levels for learner, provisional and open licence classes in all Australian states and territories? (1 mark)
 - b) Find the same information for at least one state or province in two other countries. (1 mark)
2. When you are charged with drink driving in Australia you have to go to court. In legal cases, BAC is often estimated using the *Widmark* formula (developed in 1932), which states that

$$B = \frac{A}{rW} \times 100 - Vt,$$

where B is the BAC as a percent at any time t in hours since commencing drinking, A is the amount of alcohol consumed in grams, V is the rate at which the body eliminates alcohol measured in ‰ per hour, W is the body mass in grams and r is the *Widmark factor*. The *Widmark factor* estimates the proportion of body mass that is water. The precise value of r depends on factors such as gender, age and percentage body fat, but reasonable estimates are $r \approx 0.7$ for males and $r \approx 0.6$ for females.

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- a) A standard drink contains 10 grams of alcohol. Let $V \approx 0.015\%/h$. Using **your** mass (to the nearest kg) calculate your BAC:
- i) 1 hour after you had 5 standard drinks in a very short period of time. (1 mark)
 - ii) 5 hours after you had 5 standard drinks in a very short period of time. (1 mark)
 - iii) 5 hours after you had 10 standard drinks in a very short period of time. (1 mark)
- b) For *one* of the scenarios above, calculate your BAC if you were:
- i) 10kg lighter than your current mass; and (1 mark)
 - ii) 10kg heavier than your current mass. (1 mark)
- c) For parts **ii)** and **iii)** in **a)**, calculate how long it would take before your BAC was below 0.05%. (2 marks)
3. In the Widmark formula in Q2, the absorption term, $\frac{A}{rW} \times 100$, assumes that alcohol is absorbed by the body **immediately** after consumption. Posey and Mozayani (2007) propose that

$$B = \frac{A}{rW} \times (1 - e^{-kt}) \times 100 - Vt,$$

where k is the rate at which the body absorbs alcohol, is a more appropriate formula. It has been proven that BAC depends on the presence of food in your stomach. Suppose that $k \approx 2.3$ for a full stomach and $k \approx 6$ for an empty stomach (and a standard drink contains 10 grams of alcohol and $V \approx 0.015\%/h$).

- a) Using **your** mass (to the nearest kg) calculate your BAC on both empty and full stomachs:
- i) 1 hour after you had 5 standard drinks in a very short period of time. (1 mark)
 - ii) 5 hours after you had 5 standard drinks in a very short period of time. (1 mark)
 - iii) 5 hours after you had 10 standard drinks in a very short period of time. (1 mark)
- b) For parts **ii)** and **iii)** in **a)**, *estimate* how long it would take before your BAC was below 0.05%. Show all working. (4 marks)

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4. Using Posey and Mozayani's formula, find when your BAC is at a maximum and what its maximum value is if:
- i) you drink 5 standard drinks on an empty stomach in a very short period of time. (4 marks)
 - ii) you drink 5 standard drinks on a full stomach in a very short period of time. (4 marks)
5. Consider scenarios from parts **ii)** and **iii)** in **Q2a)**.
- a) Using the Widmark formula, calculate at what time your BAC returns to zero for each of the two scenarios. (4 marks)
 - b) Long-term exposure to drugs can have serious effects on your body. Using the Widmark formula, calculate your total exposure to alcohol (area under the graph) from time $t = 0$ to when your BAC returns to zero for each of the two scenarios. (4 marks)
 - c) In **Q2a)iii)** you doubled your alcohol consumption. Did this double your total exposure to alcohol? In a short paragraph explain the effects binge drinking can have on your system. (3 marks)

Posey and Mozayani, *The estimation of BAC, Widmark revisited*, Forensic Science, Medicine and Pathology, **3** (2007) 33-39.