# SCIE1000, Tutorial Week 8.

- On this tutorial sheet you will mostly work through previous exam questions. As usual, the broad concepts and techniques we cover are more important than the specific examples. Do not try to commit lots of facts to memory; instead, know **how** to do things, and **when** certain models and approaches are appropriate.
- The midsemester exam will be held after the holiday. If you have any questions about the content so far, you can ask your tutors this week. You really should be making progress on the second project submission. **The requirements, including the due date and time, are very strict.** Do not leave it until the last minute!

# 1 Questions

1. (Final exam, 2009. Worth 4 marks, so about 4 minutes to work.) Consider the problem of finding a value of $t$ for which $e^t - 3t = 0$. Apply one step of Newton's method to calculate $t_1$, using $t_0 = 0$.

2. (Final exam, 2010. Worth 6 marks, so about 6 minutes to work.) The function $f(t) = t^2 + e^{-t}$ has a local minimum near $t = 0$. Find the approximate value of $t$ at which the local minimum occurs.

   (Hint: it may help to note that $f'(t) = 2t - e^{-t}$ and that $f''(t) = 2 + e^{-t}$. The local minimum occurs where $f'(t) = 0$. Use **one step** of Newton's method in your answer.)

3. (Final exam, 2010. Worth 4 marks, so about 4 minutes to work.) Convert a pressure of 0.1267 bar to an equivalent pressure with units mm Hg. Show all work, including a dimensional analysis. (Hint: 1 mm Hg equals 1 torr; 1 torr equals 0.0193 pounds per square inch; 7.5 torr equals $10^3$ Pa; $10^5$ Pa equals 1 bar.)

4. The gas law for an ideal gas at temperature $T$ (in kelvin, K), pressure $P$ (in atmospheres, atm), and volume $V$ (in litres, L) is $PV = nRT$ where $n$ is the number of moles of the gas and $R = 0.0821$ (with appropriate units) is the ideal gas constant.

   **(a)** Find the units of $R$.

   **(b)** Consider a sample of ideal gas containing $n$=10 mol. At a certain time the sample is at pressure $P$=8 atm which is increasing at a rate of 0.1 atm min$^{-1}$, and volume $V$=10 L which is decreasing at a rate of 0.15 L min$^{-1}$. Find the rate of change of the temperature $T$ with respect to $t$ at that time.

   (Hint: you will need to recall the *product rule* for differentiating, which you covered at school. If $y$, $A$ and $B$ are all functions of the same variable and $y = A \times B$, then $y' = A'B + AB'$.)

5. Recall that the equation for a species-area curve is $S(a) = Ca^p$, where $S(a)$ is the number of species observed in an area of size $a$, and $C$ and $p$ are constants. The points $P_1 = (10, 50)$ and $P_2 = (100, 60)$ both fall on a particular species-area curve.

   **(a)** (Final exam, 2010. Worth 4 marks, so about 4 minutes to work.) Show how a log transformation can be used to create a linear version of this curve, and sketch the linear version. On your graph, mark the points which correspond to $P_1$ and $P_2$.

   **(b)** (Final exam, 2010. Worth 4 marks, so about 4 minutes to work.) Use Part (a) to estimate the values of $C$ and $p$ in the equation $S(a) = Ca^p$.

6. (Special exam, 2010.) A certain material undergoes radioactive dcecay. At time $t = 2$ hours a sample of the material contains $10^5$ mg, and at time $t = 8$ hours the sample contains $10^4$ mg.

   **(a)** (Worth 3 marks so about 3 minutes to work.) Find the average rate of change of the sample size between $t = 2$ and $t = 8$.

   **(b)** (Worth 5 marks so about 5 minutes to work.) Find the half life of this material.

   **(c)** (Worth 3 marks so about 3 minutes to work.) At what time will there be $10^2$ mg in the sample?

**The end**