1. A tumour has the branching structure shown in the figure below, where a single precursor cell (generation 0) gives rise to 3 daughter cells (generation 1), which in turn give rise to 3 new daughter cells each (generation 2) and so on. Assume that all cells are spherical and that there are a total of 10 generations including the precursor (i.e. up to generation 9; Note that only the first 3 generations are shown in the figure below). The precursor cell has a radius of 10 µm and each daughter cell has a radius that is 80% of the radius of its parent.

(a) How many cells are produced in generation 6 and what is their radius?
(b) What is the total number of cells over all the generations combined?
(c) What is the total surface area of all the cells combined?
(d) What is the total volume in the final generation?
(e) What is the total volume of all the cells combined.

2. Calculate the area of the rhombus $OABC$ below (definition: a rhombus is a quadrilateral with four equal sides) using Riemann sums. Verify that the area is $(d_1d_2)/2$, where $d_1$ and $d_2$ are the lengths of the two diagonals: 
$f(x) = ax$
$g(x) = a(2-x)$

**Hint:** Set up two Riemann sums, one for the area under the line segment OA, and the other for the area under AB with appropriate bounds on the x axis for each sum. Set up a Riemann sum to approximate each area, and then take the limit of each sum as the number of subdivisions $n$ approaches infinity.

3. Problem 2.8 from the online problem set (Note: Use Riemann sums, and not antiderivatives to solve this problem).

4. In some situations it is possible to evaluate a definite integral without resorting to Riemann sums or antiderivatives, and instead by using simple geometrical rules. Determine the values of each of the following definite integrals without using any ‘integration techniques’. It will be helpful to sketch the regions and functions involved. Recall the formulas for areas of rectangles, triangles, and circles.

(a) \[ \int_{0}^{2} 4x \, dx, \]

(b) \[ \int_{-0.5}^{0.5} (1-2x) \, dx, \]

(c) \[ \int_{-3}^{3} \sqrt{9-x^2} \, dx. \]

5. Problem 2.17 from the online problem set.

6. Review of derivatives. Differentiate the following functions:

(a) \[ f(x) = \ln(x^2 + x) \]
(b) \[ g(x) = \frac{ax^2}{x^{1/3}} + \frac{b}{x^{1/3}} - \frac{x^{1/3}}{\sqrt{x}} \]
(c) \[ f(x) = x^x \]
(d) \[ f(\theta) = \arctan 3\theta \]
(e) \[ p(y) = \sqrt{\frac{1+y}{1-y}} \]
(f) \[ f(t) = e^{\cos t} \sin t \]