Physics 1 – Elementary Kinematics

In this section we will use the following formulae:

$$v = \frac{\Delta s}{\Delta t} \text{ (For constant speed)}$$

$$a = \frac{\Delta v}{\Delta t} \text{ (For constant acceleration)}$$

1. A car moves uniformly in a circular path with radius of 10m
   a. Suppose the car completes a loop in 15 seconds, find the speed of the car in terms of m/s. What is the *displacement* of the car?
   b. A speeding camera is set around the circular path to catch speeders, the speed limit is set at 15 km/h, will the driver of the car be caught?
   (Hint: Try to work out how much the car travels in an hour)
   c. After a while the car runs out of fuel, the car then decelerates uniformly in a straight line from its original speed in (a) to a stop in 2 seconds, calculate the acceleration (or deceleration as you may call it) of the car.
2. A rollercoaster accelerates from rest ($v = 0$) at 5 m/s^2.
   a. Suppose the rollercoaster accelerates for 3 seconds, find the resulting speed of the rollercoaster.
   b. The rollercoaster then travels at the constant speed for 5 seconds, find how far the rollercoaster has moved within these 5 seconds.
   c. Sketch a graph of the velocity of the rollercoaster with respect to time, label your axes
   d. Using the fact that the area under the v-t graph equals the displacement. Find how far the rollercoaster has travelled within the first 8 seconds of its journey
3. We will continue on the concept of using areas under graphs to our advantage.
   a. Suppose an object, moving at u m/s accelerates uniformly at a m/s^2, sketch a graph of a against t
   b. The area of the a-t graph equals to the **net change** of velocity from $t = 0$ up until that point. Using this information, derive the equation for v at a certain t:
   $$v = u + at$$
   c. The area under the v-t curve equals to the displacement. Hence, further derive the equation for s for constant a:
   $$s = ut + \frac{1}{2}at^2$$
   d. Prove the final equation for motions under a constant acceleration: (hint: use your results in b and c)
   $$v^2 = u^2 + 2as$$

4. A ball falls freely without the effect of air resistance. The object accelerates at 9.8 m/s^2 under gravity. (i.e. take $g = 9.8 m/s^2$)

a. The ball was let go **from rest** at the top of a 100m building, find the time it takes for the ball to reach the ground

b. Find the velocity of the ball when it just touches the ground

c. The ball rebounds upwards at 30 m/s, find the highest point that it will reach. (Hint: The vertical velocity of the ball is 0 at its highest point)

d. What would happen to the time taken for the ball to reach the ground if there was air resistance? (You only need to describe the effect, calculations are not required)