Section 3: The constant acceleration formulae

Exercise level 3 (Extension)

1. A particle moves with constant deceleration 6 ms^{-2} away from the origin along a straight line in the direction of positive displacement.
   (i) What must the initial velocity of the particle be if its displacement after 1 second is 18 metres?
   (ii) At what other time is the particle's displacement 18 metres?
   (iii) What is the particle's maximum positive displacement?

2. (Take **g** = 10 m s^{-2} in this question)
   An apocryphal story tells that an Oxford University examination question was once set to physics' students as follows: *how would you use a Fortin barometer to measure the height of the Clarendon Building?*
   (i) One student offered the following answer: *take it onto the roof, drop it from the edge and time its fall*. Using his method, and a constant acceleration model, what height (h_1 metres) would he conclude the Clarendon Building had if the barometer's time of fall was t_1 seconds?
   (ii) Another student suggested: *take it to the roof and lower it on the end of a piece of string until it reaches the ground, then measure the string's length*. Acknowledging those students' humour, a third student gave himself a challenge by using a bit of both. His proposal was: *(a) climb part-way up the Clarendon Building and use the string method to find the height where you are (h_2 metres); (b) time the barometer's fall when dropped by the first student, but from the instant when it passes your height to the instant at which it hits ground (t_2 seconds)*. Formulate the third student's method by expressing h_1 as a formula in terms of h_2 and t_2 only.

3. (i) *An intercity train travelling at 100 mph will take more than a mile to stop*. Use a constant acceleration model to work out from this what the maximum deceleration is. (Take 1 mile as approximately 1600 metres, and work in the usual metric units.)

   (ii) High speed trains were designed to reach 125 miles per hour while still able to stop in less than the distance of the then conventional trains. This was achieved by introduction of the so-called hydrokinetic braking system. What deceleration does this claim for such a braking system? (Again use a constant acceleration model for this calculation.)

4. A train is to stop at a station, decelerating uniformly from 100 kmh^{-1} to rest. The train is of length 100 metres, and the platform 120 metres.
   (i) If the train decelerates for 30 seconds, and the rear of the train just clears the platform end when the train comes to rest in the station, how far from the nearer end of the station platform must the driver start to brake on the approach?

(ii) What is the least deceleration required if the front of the train is still to be within the confines of the platform when starting to brake from the same distance?

(iii) How fast could the train be going if the driver applies the brake at the same distance and with the original deceleration if the train is to be within the confines of the platform?

(iv) When more lightly loaded the same train can achieve a stop from that higher speed with the rear of the train just clearing the end of the platform. What deceleration is achieved in that case?

5. A stone is thrown vertically upwards into the air at u_0 ms^{-1}. In all parts of this question give your answer in terms of g or u_0 or both.

(i) How long does it take to reach its maximum height?

(ii) How long does it take to return to its starting point?

(iii) How fast should a second stone, thrown vertically upwards at the same time as the first reaches its maximum height, be travelling in order to collide with the first stone when at the second stone's maximum height?

(iv) If those activities were repeated on the moon (where g = 2 in place of the usual 10) which of your answers would be unchanged, if any?