Equations of Motion

So far, you have used a few simple equations to calculate various aspects of motion:

Equation 1: velocity in terms of displacement

Equation 2: average velocity for constant acceleration

Equation 3: definition of acceleration

From these equations, others can be derived:

Equation 4: displacement based on initial velocity and acceleration

Equation 5: velocity squared without reference to time

# Problem Solving Process

When solving problems using these equations (and others!), it is helpful to follow a consistent process:

1. Neatly write down the quantities that have been given in the question, using positive and negative values to indicate directions
   * Some reading between the lines may be necessary: if something stops, ***v*** = 0; if it is dropped or starts from rest, then ***u*** = 0; if it is thrown upwards, its vertical velocity is 0 at its highest point
2. Convert all units to SI units (m, kg, s, etc.)
3. Identify the quantity that the question is asking you to calculate
4. Draw a simple diagram of the situation if more than one direction is involved
5. Based on the quantities that you have been given and asked for, select an appropriate equation
   * You must choose a formula which only has one unknown
   * Sometimes you won’t be able to calculate the value you’re looking for directly
   * Don’t use equation 4 to find *t* unless ***u*** is 0
6. Avoid or minimise rounding while working out; round to 3 significant figures at the end, using scientific notation if necessary
7. Include units with your answer and specify a direction if the quantity is a vector and directions are given in the question
8. Re-read the question and:
   * Check that your answer makes sense: if you find that the mass of a truck is 0.100 kg, or its length is 1.00 × 103 m, something is obviously wrong
   * Ensure you have sufficiently answered the question that was asked

# Questions

1. Captain Courageous is flying through space at 208.8 km h-1 when he sees space pirates attacking an unarmed spaceship. He accelerates at 15.6 m s-2 for 50.0 m to reach the spaceship. What is his final velocity as he reaches it?
2. A remote-controlled car is travelling at 2.00 m s-1 when it accelerates at 1.80 m s-2 to cover 5.00 m. How long did it take to cover this distance?
3. In a sprint race Carl can accelerate from rest to 11.13 m s-1 in 3.25 s. Calculate Carl’s average acceleration.
4. In an attempt on the world land speed record, a rocket car accelerates from an initial velocity to 96.0 m s-1 east in 2.30 s. If the rocket car’s acceleration was 30.0 m s-2, what was its initial velocity?
5. Caroline’s sports car accelerates from zero to 45.0 km h-1 in 2.65 s in first gear. What is the sports car’s average acceleration?
6. In his motorcycle log book, Adam notes that his motorcycle can accelerate from 21.8 km h-1 to 28.6 km h-1 in 1.70s.
   1. What is the magnitude of the acceleration of his motorcycle?
   2. If he maintained this acceleration how much longer would it take to reach 62.6 km h-1?
7. Vincent’s car has a speed of 12.5 m s-1 when he steps on the accelerator. This accelerates his car at 4.50 m s-2 for 7.00 s. He then applies the brakes that decelerate his car at 11.0 m s-2 till it comes to a rest. All this happens on a straight road. Determine how far he has driven.
8. Jack and Jill are running down the road at 2.60 m s-1. When Jill stops, Jack accelerates for 2.00 seconds to reach a velocity of 3.20 m s-1 then stops suddenly.
   1. Calculate Jack’s acceleration.
   2. At this point, how far apart are the two children?

# Bonus Questions

Use equations 1, 2, and 3 to derive equation 4. (Hint: put equations 1 and 2 together, then rearrange equation 3 to find ***v***.)

Use equations 1, 2, and 3 to derive equation 5. (Hint: start the same way you did when deriving equation 4, and consider which variable does not appear in equation 5.)