01 During a performance, an ice skater is travelling with a velocity of 4 m/s.

01.1 She decelerates uniformly to a velocity of 1 m/s at 0.5 m/s^2.
How far does she travel in this time?

$v^2 - u^2 = 2\,a\,s$
$(1)^2 - (4)^2 = 2\,(-0.5)\,(s)$
$1 - 16 = -s$
$-15 = -s$
s = 15 metres

Remember that u = initial velocity and v = final velocity

01.2 Later in the performance, she accelerates at a rate of 1.2 m/s^2 from a velocity of 2.2 to a velocity of 3.1 m/s. How long does this take?

$a = (v - u) \div t$
$t = (v - u) \div a$
$t = (3.1 - 2.2) \div 1.2$
$t = 0.9 \div 1.2$
t = 0.75 seconds

02 A bus accelerates uniformly from 0 to 50 km/h in 15 seconds. It then maintains this speed for a further 45 seconds.

02.1 Show that 50 km/h is equivalent to a speed of approximately 13.9 m/s.

50 km/h = 50,000 m/h (1 km = 1000 m)
50,000 ÷ 3,600 = **13.9 m/s** (1 d.p.) (1 hour = 60 × 60 s = 3,600 s)

Hint: 50 km/h means that the bus will travel a distance of 50 km if it continues at this speed for 1 hour (in other words it will travel 50,000 m in this time).

Because there are 3,600 seconds in 1 hour, we divide 50,000 by 3,600 to calculate the number of metres it covers in 1 second (i.e. its speed in m/s).

02.2 Calculate the acceleration of the bus in its first 15 seconds of motion.

$a = \Delta v \div t = (v - u) \div t = (13.9 - 0) \div 15 =$ **$0.93\ m/s^2$**

02.3 Calculate the total distance travelled by the bus during this minute.

In first 15 seconds:

Either method (a)

$v^2 - u^2 = 2\ a\ s$

$13.9^2 - 0^2 = 2\ (0.93)\ (s)$

$1.86\ s = 193.21$

$s_1 = 103.9\ m$

Or method (b)

Average speed = 13.9 ÷ 2 = 6.95 m/s

Distance, $s_1 = 6.96 \times 15 = 104.25\ m$

There are other ways of doing this question (which you'll meet if you study Physics at A-level, which you definitely should since it's amazing), but these two are probably the most straightforward.

They give slightly different distances because we have rounded the acceleration answer from the previous question to 2 decimal places.

From 15 – 60 seconds:

$s_2 = v\ t = 13.9 \times 45 = 625.5\ m$

Total distance = $s_1 + s_2 =$ **729.4 m** (or **729.75 m**) (1 d.p.)

03 A car accelerates uniformly from rest to its top speed of 40 m/s at a rate of 4 m/s^2.

03.1 Calculate the distance which the car travels whilst accelerating to its top speed.

Values given:

$u = 0$

$v = 40\ m/s$

$a = 4\ m/s^2$

Distance calculation:

$v^2 - u^2 = 2\ a\ s$

$40^2 - 0^2 = 2\ (4)\ (s)$

$8\ s = 1600$

s = **200 m**

03.2 It then travels at its top speed for some time, before decelerating to rest at a rate of 8 m/s^2. If it travelled a distance of 1 km in total, how long did its journey take?

Acceleration phase:

$u = 0$
$v = 40$ m/s
$a = 4$ m/s^2

$a = (v - u) \div t$
$4 = (40 - 0) \div t$
$t_1 = 40 \div 4 = 10$ s

Deceleration phase:

$u = 40$ m/s
$v = 0$
$a = -8$ m/s^2

$a = (v - u) \div t$
$t = (v - u) \div a$
$t_3 = (0 - 40) \div (-8) = 5$ s

$v^2 - u^2 = 2as$
$0^2 - 40^2 = 2(-8)(s)$
$-1600 = -16s$
$s = 100$ m

Uniform speed phase:

$v = 40$ m/s
$s = 1000 - 200 - 100 = 700$ m
$t_2 = s \div v = 700 \div 40 = 17.5$ s

Total time taken $= t_1 + t_2 + t_3 = 10 + 17.5 + 5 =$ **32.5 seconds**

This is a challenging question, and you would be very unlucky indeed if it was to come up in your exam, but you do have all of the skills to answer it, so technically, it could come up!

Notice how we have split the journey into three phases: acceleration (at the start), deceleration (at the end) and uniform speed (in the middle). We used $a = \Delta v \div t$ to calculate the amount of time which the car spent accelerating and decelerating.

Next, by calculating how *far* the car travelled whilst accelerating and decelerating, we were able to work out *how far* it travelled at uniform speed, and then using $s = v\,t$, calculate in turn how *long it spent* travelling at uniform speed. We then just had to add up our three times to calculate the final answer.

03.3 Calculate the average speed of the car for its whole journey.

Average speed = total distance travelled ÷ total time taken
Average speed = 1000 ÷ 32.5 = **30.8 m/s** (1 d.p.)