Physics Induction Homework

Use A4 lined paper to complete the 8 questions (3 on this side, 5 on the other), you must show your working out.

Acceleration

Acceleration — the Change in Velocity Every Second

Acceleration is the **rate of change** of **velocity**. Like velocity, it is a **vector quantity** (it has a size and a direction). It is measured in **metres per second squared** (ms^{-2}).

$$\textbf{Acceleration (in metres per second}^2\textbf{)} = \frac{\textbf{change in velocity (in metres per second)}}{\textbf{time taken (in seconds)}}$$

So: $$\textbf{Acceleration} = \frac{\textbf{final velocity} - \textbf{initial velocity}}{\textbf{time taken}}$$

Or in symbols: $a = \frac{v-u}{t} = \frac{\Delta v}{t}$ where u is the initial velocity, v is the final velocity and Δv is the change in velocity.

You'll often only need to think about velocities in **one dimension**, say left to right. But you still need to recognise the **difference** between velocities from right to left and velocities from left to right.

Choose a direction to be **positive** — below, we'll use **right**. All velocities in this direction will from now on be positive, and all those in the **opposite direction** (left) will be **negative**.

Deceleration is negative acceleration and acts in the **opposite direction** to motion.

EXAMPLE: A car starts off moving to the right at 15.0 metres per second. After 30.0 seconds it is moving to the left at 5.25 metres per second. What was its acceleration during this time?

$u = 15.0\ ms^{-1}$ to the right $= +15.0\ ms^{-1}$

$v = 5.25\ ms^{-1}$ to the left $= -5.25\ ms^{-1}$

So, $a = \frac{v-u}{t} = \frac{-5.25-15.0}{30.0} = \frac{-20.25}{30.0} = \mathbf{-0.675\ ms^{-2}}$

(The acceleration is negative so it's to the left.)

EXAMPLE: A dinosaur accelerates from rest at 4.00 ms^{-2} to the right. If its final velocity is 25.0 ms^{-1} to the right, how long does it accelerate for?

$u = 0.00\ ms^{-1}$ $v = 25.0\ ms^{-1}$ to the right $= +25.0\ ms^{-1}$

$a = \frac{v-u}{t}$, multiplying both sides by t gives $a \times t = v - u$,

and then dividing both sides by a gives $t = \frac{v-u}{a}$. So, $t = \frac{25.0-0}{4.00} = \mathbf{6.25\ s}$

A seller rating is the key thing to check when buying a car online...

1) A train has an initial velocity of 12.8 ms^{-1} to the left. After 22.0 seconds it is moving to the right at 18.3 ms^{-1}. What was its average acceleration during this time?
2) A ship accelerates at a uniform rate of 0.18 ms^{-2} east. If its initial velocity is 1.5 ms^{-1} east and its final velocity is 4.5 ms^{-1} in the same direction, how long has it been accelerating for?
3) A rabbit is hopping at a constant speed when he begins decelerating at a rate of 0.41 ms^{-2}. What was the rabbit's initial hopping speed if it takes him 3.7 seconds to come to a stop?

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Acceleration Due To Gravity

The **Acceleration** Due to **Gravity** is **g**

When an object is dropped, it accelerates downwards at a constant rate of roughly 9.81 ms^{-2}. This is the **acceleration due to gravity** and it has the symbol ***g***.

It usually seems sensible to take the upward direction as positive and down as negative, making the acceleration due to gravity **$-9.81\ ms^{-2}$**.

EXAMPLE: What is the vertical velocity of a skydiver 5.25 seconds after she jumps out of a plane that is travelling at a constant altitude? (Ignore air resistance and horizontal motion.)

$u = 0$

$a = -9.81\ ms^{-2}$

You can rearrange $a = \frac{v-u}{t}$ to give $v = u + (a \times t)$.

So $v = 0 + (-9.81 \times 5.25)$

$= 0 - 51.5025$

$= -51.5025$ = **$51.5\ ms^{-1}$ down (to 3 s.f.)**

EXAMPLE: A diver jumps up off a springboard. After 2.50 seconds he hits the water travelling downwards at 18.0 ms^{-1}. What was his initial vertical velocity? (Ignore air resistance and horizontal motion.)

$v = 18.0\ ms^{-1}$ down $= -18.0\ ms^{-1}$

$a = -9.81\ ms^{-2}$

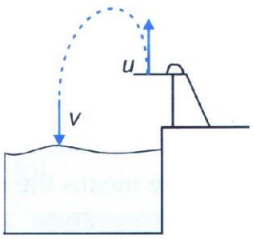
You can rearrange $a = \frac{v-u}{t}$ to give $u = v - (a \times t)$.

So, $u = -18.0 - (-9.81 \times 2.50)$

$= -18.0 - (-24.525)$

$= -18.0 + 24.525$

$= 6.525$ = **$6.53\ ms^{-1}$ upwards (to 3 s.f.)**



This isn't falling, it's learning with style...

You can ignore air resistance in these questions. Hint — drawing a little diagram can help.

1) An apple falls from a tree and hits the ground at 4.9 ms^{-1}. For how long was it falling?
2) A stone is thrown straight downwards. It hits the ground at 26.5 ms^{-1} after 2.15 seconds. What velocity was it thrown at?
3) A metal rod falls from a stationary helicopter. What velocity does it hit the ground at, 10.0 seconds later?
4) A sandbag is dropped from a stationary hot-air balloon. It hits the ground at a velocity of 24.5 metres per second. How long was it falling for?
5) A ball is thrown straight upwards. After 1.90 seconds it is moving downwards at 10.7 ms^{-1} and is caught. With what velocity was it thrown?