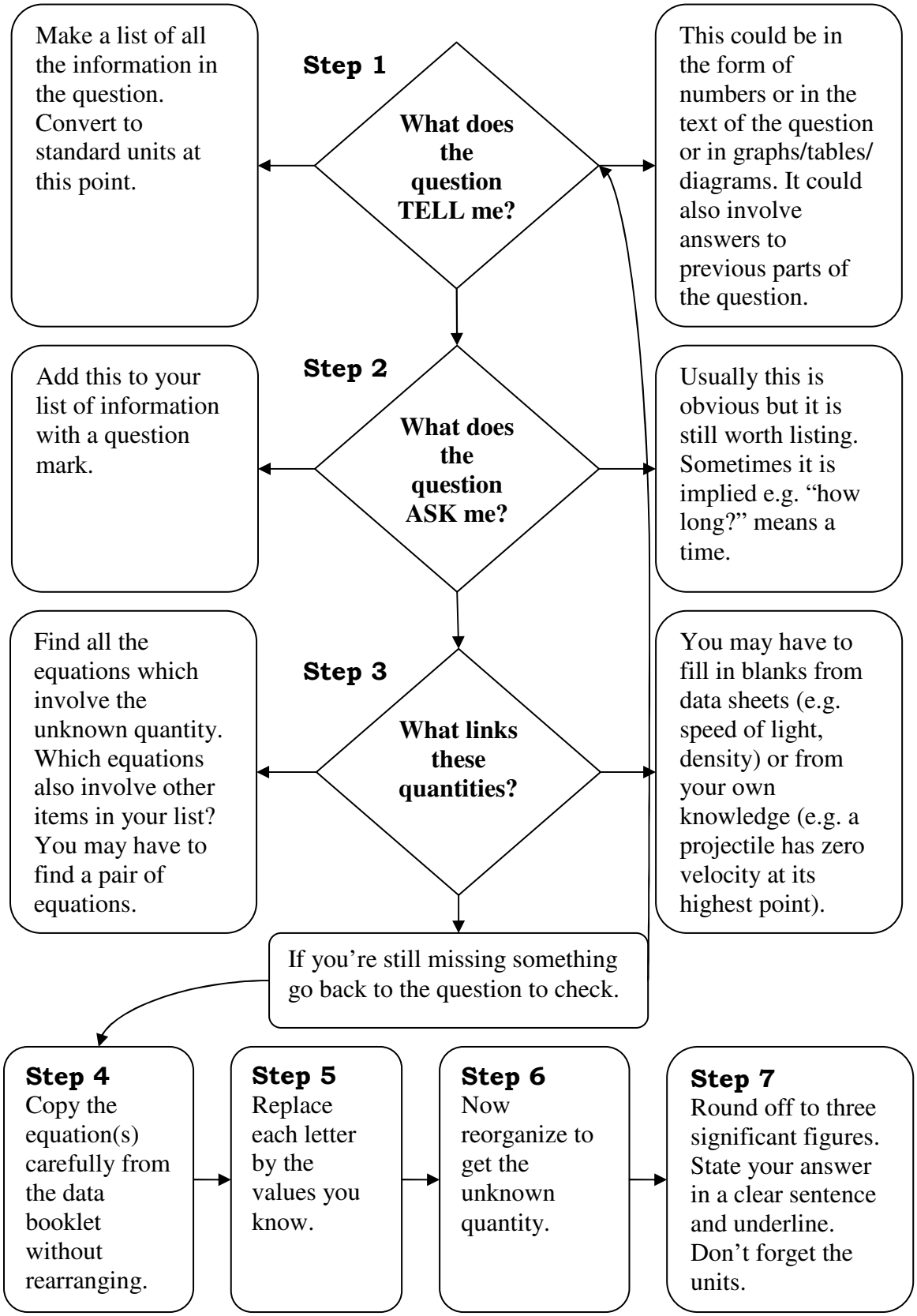
# Problem Solving in Physics

It is important to establish a methodical approach to problem solving numerical examples as soon as possible. This means getting used to doing this even on the simplest problems so that it becomes a habit. It is vital to remember the first three steps: What does the question TELL me? – What does the question ASK me? – What links these quantities?



# Problem Solving in Physics – Worked Examples

The comments in italics are there to help explain my reasoning. You could imagine these statements in your head. You would not be expected to write them. Similarly you don't have to write Step 1, Step 2, etc. It is important to get into the habit of writing out all the other parts, though.
These examples are simple to demonstrate the principles involved but the method can be applied to much more difficult examples. Don't worry if you haven't met some of the equations yet; just concentrate on the methodical approach.

| **Example 1** | At the school sports day, the winner of the 100m race had a time of 11.5s. What was their average speed? (2) |
|---|---|
| ***Step 1*** | $d = 100m$ |
| | $t = 11{\cdot}5s$ |
| ***Step 2*** | $\bar{v} = ?$ |
| ***Step 3*** | *From the data booklet:* |
| | $d = \bar{v}\,t \qquad \bar{v} = \frac{u+v}{2}$ |
| ***Step 4*** | *I know d and t so use* |
| | $d = \bar{v}\,t$ |
| ***Step 5*** | $100 = \bar{v} \times 11{\cdot}5$ |
| ***Step 6*** | $\bar{v} = \frac{100}{11{\cdot}5}$ |
| | $\bar{v} = 8{\cdot}695652174\ ms^{-1}$ |
| ***Step 7*** | The winner's average speed was $\underline{8.70\ ms^{-1}}$. |

| **Example 2** | A radio station transmits at 99.6 MHz. What is the wavelength of the radio waves? (3) |
|---|---|
| ***Step 1*** | $f = 99{\cdot}6\ MHz = 99{\cdot}6 \times 10^6\ Hz$ *(No need to simplify this further)* |
| ***Step 2*** | $\lambda = ?$ |
| ***Step 3*** | *From the data booklet:* |
| | $v = f\lambda$ |
| ***Steps 1-3*** | *I know f but not v. Go back to steps 1 to 3. Can I find it in the question or fill it in from a data sheet?* |
| | *Yes. Radio waves travel at the speed of light. This is aggressive reading – finding the information required.* |
| | $v = 3 \times 10^8\ ms^{-1}$ |
| ***Step 4*** | $v = f\lambda$ |
| ***Step 5*** | $3 \times 10^8 = 99{\cdot}6 \times 10^6 \times \lambda$ |
| ***Step 6*** | $\lambda = \frac{3 \times 10^8}{99{\cdot}6 \times 10^6}$ |
| | $\lambda = 3{\cdot}012048193\ m$ |
| ***Step 7*** | The wavelength of the radio waves is $\underline{3.01\ m}$. |
| | *NB the 3 marks imply that something will have to be read from a graph/table or data sheet or that it is a two step calculation.* |

| | |
|---|---|
| **Example 3** | A car of mass 500 kg is travelling at 10 $ms^{-1}$. It then doubles its speed in 5s.<br>a) What is its acceleration? (2)<br>b) What unbalanced force would be needed to accelerate it? (2) |
| ***Step 1*** | a) $m = 500\,kg$<br>$u = 10\,ms^{-1}$<br>$t = 5\,s$<br>$v = 2 \times u = 2 \times 10 = 20\,ms^{-1}$ *(NB v is described in words)* |
| ***Step 2*** | $a = ?$ |
| ***Step 3*** | *From the data booklet:*<br>$F = m\,a$ $\qquad a = \frac{v-u}{t}$ |
| ***Step 4*** | *I know v,u and t so use*<br>$a = \frac{v-u}{t}$<br>*I do know m in the other formula but I can't see any obvious way of calculating F from the info available. It is also worth noting that part b asks me to calculate F so I can't know it now. Lastly only 2 marks so not likely to be a two step calculation.* |
| ***Step 5*** | $a = \frac{20-10}{5}$ |
| ***Step 6*** | $a = \frac{10}{5}$<br>$a = 2\,ms^{-2}$ |
| ***Step 7*** | The car's acceleration was <u>2 $ms^{-2}$</u>. |
| ***Step 1*** | b) *You wouldn't necessarily have to list all the variables again if your list from part a) was clear. I do so here for completeness.*<br>$m = 500\,kg$<br>$u = 10\,ms^{-1}$<br>$t = 5\,s$<br>$v = 20\,ms^{-1}$<br>$a = 2\,ms^{-2}$ *(From part a) above)* |
| ***Step 2*** | $F = ?$ |
| ***Step 3*** | *From the data booklet:*<br>$F = m\,a$ $\qquad E_W = F\,d$ |
| ***Step 4*** | *I know m and a so use*<br>$F = m\,a$ |
| ***Step 5*** | $F = 500 \times 2$ |
| ***Step 6*** | $F = 1000\,N$ |
| ***Step 7*** | The unbalanced force to accelerate the car was <u>1000 N</u>. |

| | |
|---|---|
| **Example 4** | Alisha is investigating water waves on her local pond. She measures their frequency (6.5Hz) and their wavelength (0.55m). How long would it take them to travel from the centre of the pond to the edge, a distance of 12m? (3) |
| ***Step 1*** | $f = 6{\cdot}5\ Hz$<br>$\lambda = 0{\cdot}55\ m$<br>$d = 12\ m$ |
| ***Step 2*** | $t = ?$ *Implied rather than obvious – "how long would it take?" rather than "calculate the time?"* |
| ***Step 3*** | *From the data booklet:*<br>$d = vt \qquad a = \frac{v-u}{t} \qquad P = \frac{E}{t}$ *etc…* |
| ***Step 4*** | *I know d which suggests the first equation. f and λ don't figure in any of these equations but can be used to calculate v from v=fλ. (Hence the three marks) We can then use the first equation.*<br>$v = f\lambda$ |
| ***Step 5*** | $v = 6{\cdot}5 \times 0{\cdot}55$ |
| ***Step 6*** | $v = 3{\cdot}575\ (ms^{-1})$ *Notice that we don't round off until the final answer and that units aren't necessary either.* |
| ***Step 4*** | *I now know v and t so use*<br>$d = vt$ |
| ***Step 5*** | $12 = 3{\cdot}575 \times t$ |
| ***Step 6*** | $t = \frac{12}{3{\cdot}575}$<br>$t = 3{\cdot}35664336\ s$ |
| ***Step 7*** | The waves would take <u>3.36 s</u> to reach the edge of the pond. |