Answering Questions in Physics

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Lesson Objectives

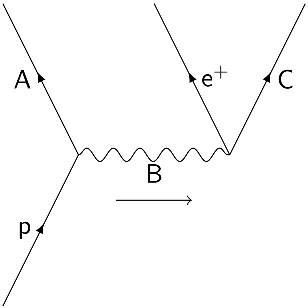
1. To answer some exam-style questions about the four forces.
2. To understand how to approach (numerical) questions in physics.
3. To practise question-answering skills.
4. (Maybe) To start particle classification.

Textbook pp. 13–15

1 β^+ decay

(a) Name the fundamental interaction responsible for β^+ decay.

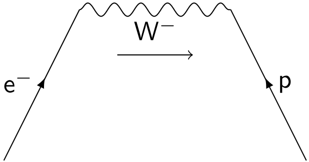
(b) β^+ decay may be represented by the following diagram. Name the particles A, B and C.



2 An electron may interact with a proton in the following way:

$$e^{+}p \rightarrow n\nu_{e}.$$

(a) Name the fundamental force responsible for this interaction.
(b) Complete the diagram for this interaction and label all the particles involved.



3 (a) Give an example of an exchange particle other than a W^+ or W^- boson, and state the fundamental force when it is produced.

(b) State what role exchange particles play in an interaction.

Questions on four forces 4

4 (a) State 3 differences between a W^+ boson and a virtual photon.

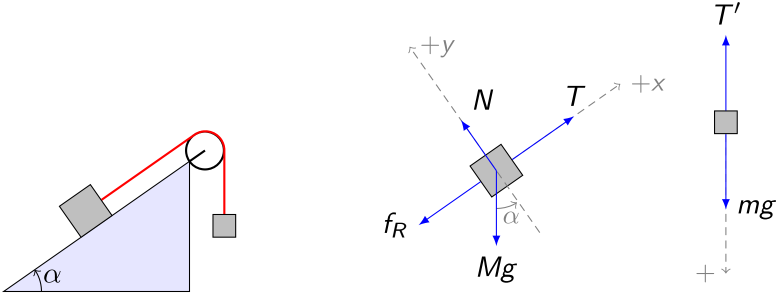
(b) State the approximate range of the W^+ boson and estimate its lifetime, given that it cannot travel faster than light.

Write down the physics!

In answering problems to learn physics, the reasoning behind the answer is usually much more important than the answer itself.
This means there should be some **words** amongst the equations and numbers.
It is very often a good idea to write down what is known and what is required.
If you are using a physical law or principle, state what it is (e.g. conservation of energy).

Energy of γ ray photon	$\longrightarrow$	Rest Energy of e^- and e^+	$+$	Kinetic Energy of e^- and e^+

If appropriate, draw a diagram.



Example

What horizontal force F (applied at the axle) is required to push a wheel of weight W over a block of height h?

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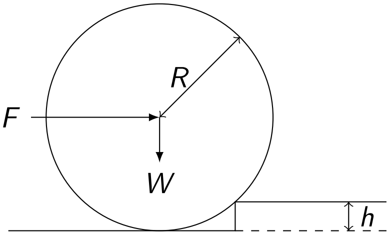

Working...

Never submit an answer that is just a bunch of numbers multiplied/divided/added/subtracted. This type of answer makes no sense at all, is not physics, and will only confuse and irritate the reader.

$$v = \left(\frac{2 \times (3 \times 10^8)^2}{8.9 \times 10^{-28}} \times (1.67 \times 10^{-27} - 8.9 \times 10^{-28}) \right)^{\frac{1}{2}}$$
$$= 3.97 \times 10^8.$$

Working 2...

In fact, you will find it is much clearer if you try to stay in symbols for as far as possible in your answer, and write down the general form of any equation you are using before putting any numbers in.

$$\text{proton rest energy}(mc^2) \longrightarrow \text{kaon rest energy} + \text{kaon K.E.}(E = \frac{1}{2}mv^2)$$

$$2m_{\mathrm{p}}c^2 = 2m_{\mathrm{K}^0}c^2 + 2\left(\frac{1}{2}m_{\mathrm{K}^0}v^2\right)$$

$$2m_{\mathrm{p}}c^2 = 2m_{\mathrm{K}^0}c^2 + m_{\mathrm{K}^0}v^2$$

$$m_{\mathrm{K}^0}v^2 = 2m_{\mathrm{p}}c^2 - 2m_{\mathrm{K}^0}c^2$$

$$v^2 = \frac{2c^2\left(m_{\mathrm{p}} - m_{\mathrm{K}^0}\right)}{m_{\mathrm{K}^0}}$$

$$v = \left(\frac{2c^2}{m_{\mathrm{K}^0}}(m_{\mathrm{p}} - m_{\mathrm{K}^0})\right)^{\frac{1}{2}}.$$

Make sure when you **do** start working with physical quantities, you include the units:

$$
\begin{aligned}
v &= \left(\frac{2c^2}{m_{\mathrm{K}^0}}(m_{\mathrm{p}} - m_{\mathrm{K}^0})\right)^{\frac{1}{2}} \\
&= \left(\frac{2 \times (3 \times 10^8\,\mathrm{m\,s^{-1}})^2}{8.9 \times 10^{-28}\,\mathrm{kg}} \times (1.67 \times 10^{-27}\,\mathrm{kg} - 8.9 \times 10^{-28}\,\mathrm{kg})\right)^{\frac{1}{2}} \\
&= \left(\frac{2 \times (3 \times 10^8\,\mathrm{m\,s^{-1}})^2 \times 7.8 \times 10^{-28}\,\cancel{\mathrm{kg}}}{8.9 \times 10^{-28}\,\cancel{\mathrm{kg}}}\right)^{\frac{1}{2}} \\
&= \left(1.58 \times 10^{17}\,\mathrm{m^2\,s^{-2}}\right)^{\frac{1}{2}} \\
&= 3.97 \times 10^8\,\mathrm{m\ s^{-1}}.
\end{aligned}
$$

Units

Always specify the units for all physical quantities (especially in the lines before the final answer as it allows you to make sure the units are consistent and work out to the answer's unit). The value of a physical quantity is equal to the product of a *numerical value* and a *unit*:

$$\text{physical quantity} = \text{numerical value} \times \text{unit}.$$

e.g. the physical quantity called the wavelength λ of one of the yellow sodium lines has the value

$$\lambda = 5.896 \times 10^{-7}\,\mathrm{m},$$

where m is the symbol for the unit of length called the metre. This may equally well be written in the form

$$\lambda/\mathrm{m} = 5.896 \times 10^{-7}.$$

Using a calculator

Don't be tempted to calculate too early in your answer, or to try anything other than very simple maths in your head.

You need to be able to use data correctly in an equation and get an answer.

Always give your answer to a reasonable number of significant figures. Just because your calculator gives you answers to 7 figures does not mean that they are all significant. A guide is the number of significant figures in the problem – if the mass of the electron is given as 6.63×10^{-34} J s rather than $6.626\,068\,96(33) \times 10^{-34}$ J s, it is a good indication that not more than 2 or 3 significant figures are expected in the answer.

Sanity Check!

What is wrong with these values:

- distance travelled by car $= 9.46 \times 10^{15}$ m
- speed of bicycle $= 18.06\,\mathrm{m\,s}^{-}1$
- wavelength of γ ray $= 3.2 \times 10^{-7}$ m
- temperature of solid CO_2 $= -416\,^{\circ}$C
- width of human hair $= 7.21 \times 10^{-11}$ m
- temperature of water $= 523$ K
- wavelength of UV $= 1.2 \times 10^{-4}$ m
- density of oxygen $= 2.48 \times 10^{3}\,\mathrm{kg\,m}^{3}$
- energy of space shuttle launch $= 1.22 \times 10^{34}$ J
- charge on electron $= 1.84 \times 10^{-18}$ C

Can you match these up?

Strong | holding nucleus together | charge | graviton | ∞ m

Weak | ∞ m | attractive / repulsive | always attractive | π^0, g

Electromagnetic | 10^{-18} m | 10^{-15} m | particle decays | mass

Gravity | photon | W^-, W^+, Z^0 | all particles

only particles made of quarks