

EXERCISES ON THE ELECTROMAGNETIC SPECTRUM

BY

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Tolentino Tuition, Year 10 Physics

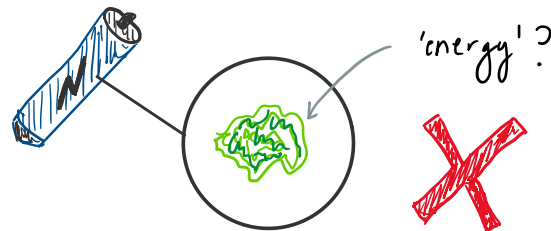
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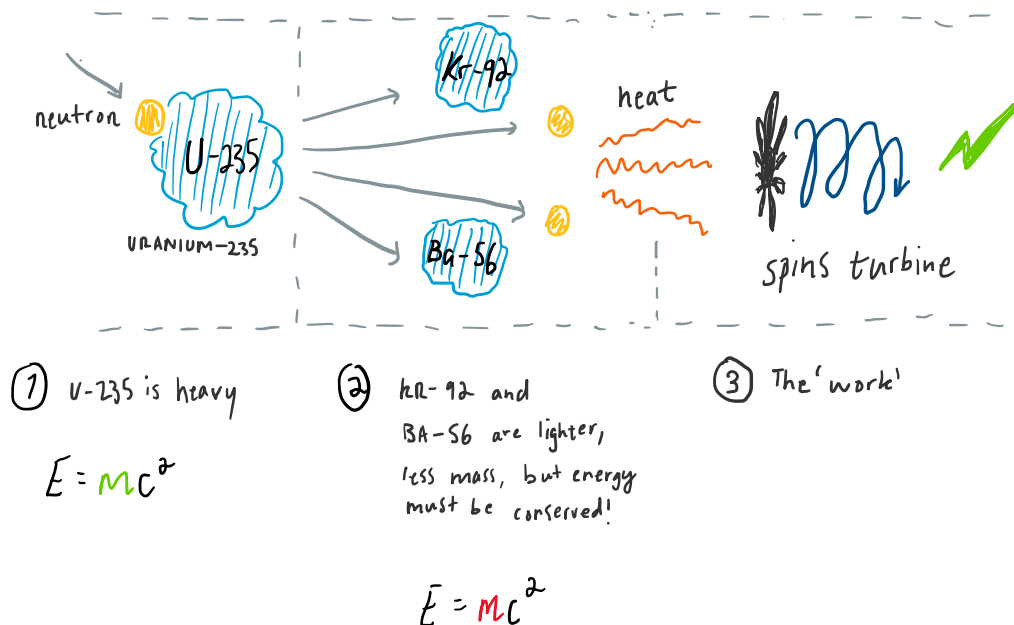
EXERCISE 1

What is energy? It is not a tangible thing - for instance, if we open up a battery, we will not find a tangible substance that is itself 'energy':



Rather than a being a tangible thing, energy is instead a *number* that we measure or calculate that describes a *property* of tangible things.

The *property* that energy is a measurement of is the capacity of a tangible object to do some kind of 'work':



1. Can you identify the 'tangible object' and the 'work'?

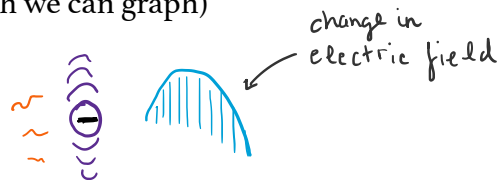
EXERCISE 2

Electromagnetic radiation describes the movement of energy that happens when a charged atomic particle, for instance an electron, is accelerated by an electric field, causing it to move.

For example, heat may cause an electron to accelerate/vibrate (as you may know from collision theory):



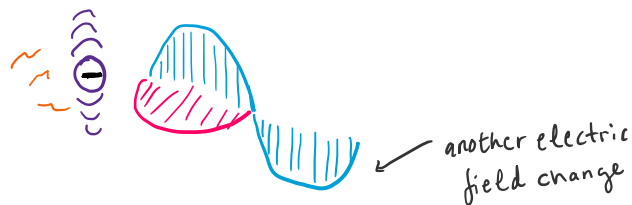
This vibration changes the electric field surrounding the electron (which we can graph)



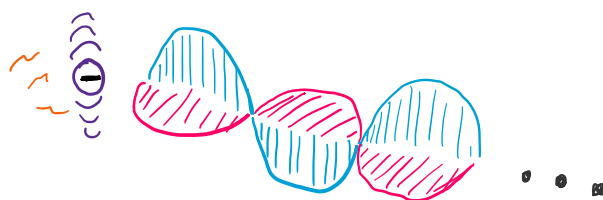
According to Maxwell's theory of electromagnetism, a changing electric field creates a perpendicular magnetic field:



Maxwell's theory also states that a changing *magnetic* field creates a perpendicular electric field (but a bit further out):



And so on...



The model that we construct to describe this electromagnetic chain reaction is called a transverse wave.

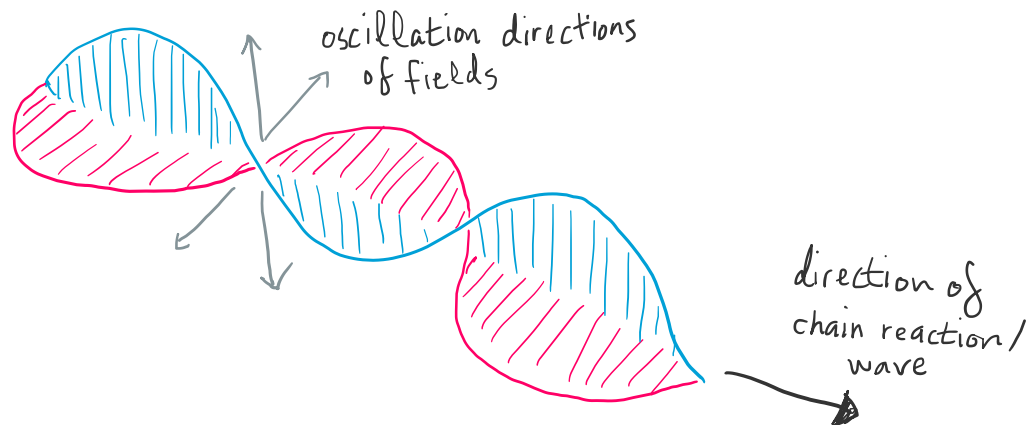
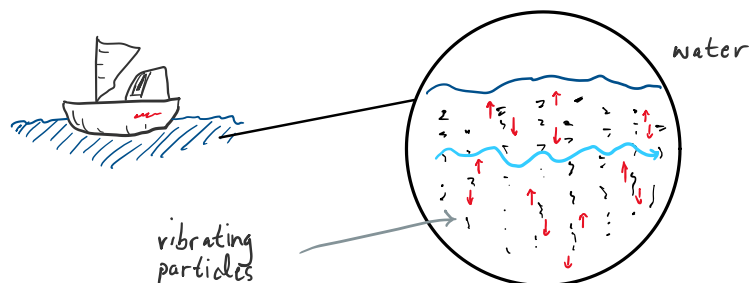


Figure 1. Transverse electromagnetic wave

1. Based on Figure 1, can you complete the below definition for a transverse wave?

A transverse wave is a wave wherein the field oscillates _____ to the direction that the wave/energy travels.

2. Given what you have learned from **Exercises 1 and 2**, can you explain what electromagnetic radiation is?
3. Electromagnetic waves are distinct from mechanical waves. Mechanical waves require consecutive particles to physically vibrate in order for mechanical waves/energy to propagate:

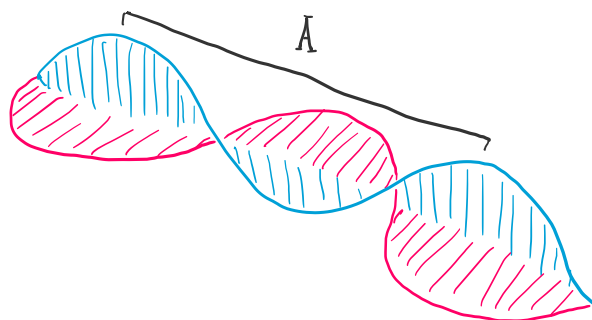


Given this information, why do you think that electromagnetic waves 'don't require a medium' in order to propagate?

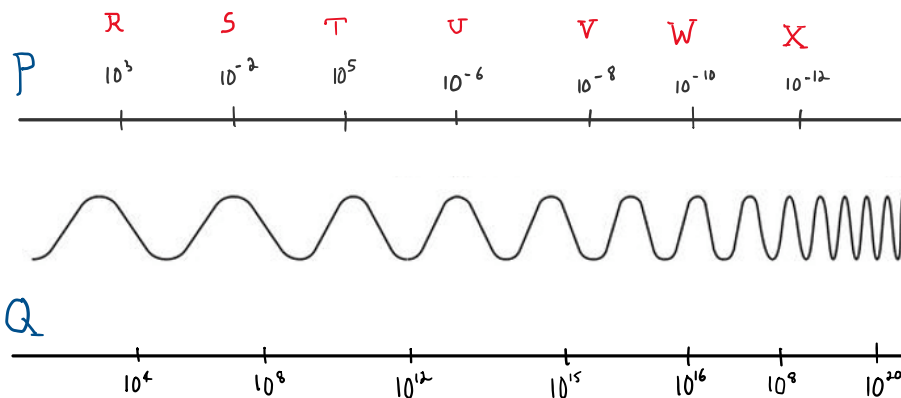
EXERCISE 3

As electromagnetic radiation can be modelled using wave functions, we can use the *wave properties* discussed last lesson to describe electromagnetic waves.

1. What wave property is represented by *A* below?



2. The range of *wavelengths* and *frequencies* spanned by electromagnetic radiation can be represented by an 'electromagnetic spectrum':



- A. What wave properties do axis *P* and *Q* represent?
- B. Which letter corresponds to:
 - i. Visible light
 - ii. The type of electromagnetic waves with the lowest/highest energy? (and why?)
 - iii. The type of electromagnetic wave with the second lowest frequency
 - iv. The type of electromagnetic wave with the third greatest wavelength

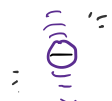
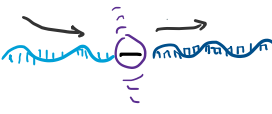
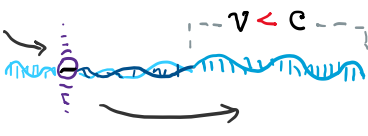
EXERCISE 4

We can calculate the speed of an electromagnetic wave (v) using:

$$\text{wave speed} \rightarrow v = f \lambda$$

frequency wavelength

1. In a theoretically perfect 'vacuum' (a space devoid of particles), all electromagnetic waves will travel at a speed of c , regardless of frequency. Why do you think that this is the case, and what is c ?
2. When an electromagnetic (light) wave moves through a medium (a substance containing particles), its speed decreases. This happens, broadly, due to the following phenomena:

The oscillating electric field of the incoming electromagnetic wave hits the atoms in the medium.	
This field makes the electrons in the medium's atoms vibrate	
As we have learned previously, these electron vibrations create their own electromagnetic waves.	
The original light wave and the new secondary waves combine, producing a wave that travels at a slower velocity than the speed of light in a vacuum.	

Given the above information, can you explain why the speed of electromagnetic waves decreases for denser and denser mediums? (e.g. gas to liquid to solid)