PHYSICS SCHOLARSHIP 2014

CALCULATORS ARE NOT TO BE USED

Total marks available = 33

MOST OF THE MARKS IN THESE QUESTIONS ARE FOR SHOWING HOW WELL YOU CAN THINK. THE FINAL ANSWERS ARE LESS IMPORTANT THAN SHOWING THAT YOU CAN THINK AND WORK LOGICALLY.

You must show your working out at all stages and clearly state any assumptions that you are making.

Where you can, use powers of ten to show very big or very small numbers. For example 1,000,000 = 1.0×10^6

Recently, scientists at The Arecebo Radio Telescope (pictured below) picked up television signals that had first been broadcast 50 years ago.



TV signals are "carried" by Very High Frequency radio waves, which can be detected by radio telescopes.

Scientists might have hoped they were detecting signals transmitted by aliens on another planet, but the more likely explanation is that they were detecting TV signals that had been broadcast from Earth and then bounced off an object in deep space – they were picking-up a radio wave "echo".

Question 1

1. Radio waves are one example of an electromagnetic wave. Another example is visible light.

Can you name a third? [1]

Question 2

The TV signals were detected 50 years after they had been transmitted.

How long is 50 years in seconds? (1 year is approximately 3×10^7 s) [2]

Question 3

All electromagnetic waves travel at the speed of light (3×10^8 m/s).

a. How far, **in metres**, did the signals travel in 50 years? [4]

b. How far, in **kilometres**, did the signals travel in 50 years? [1]

The intriguing TV signals were thought to have reflected off an object far, far away from Earth.

c. How far away, **in metres**, was the mystery reflector? [1]

Question 4

Scientists often measure large distances in light years. 1 light year is defined as the distance light travels in 1 year.

a. How far, **in light years**, did the signals travel? [1]

b. How far away, **in light years**, is the mystery reflector? [1]

Question 5

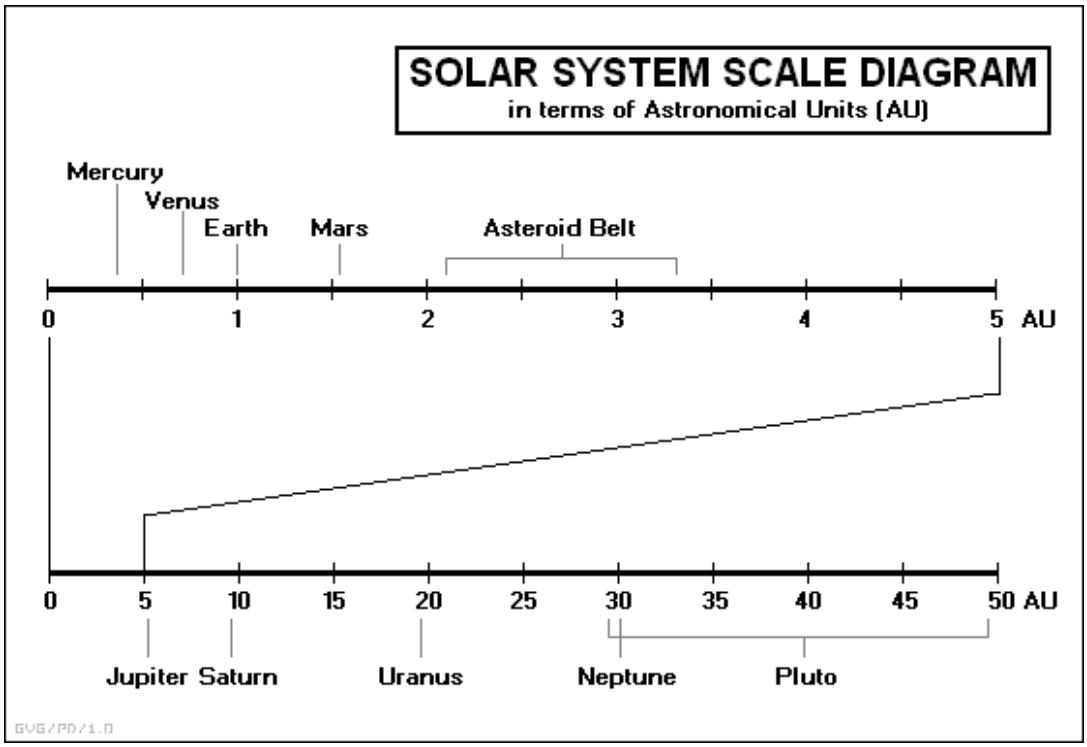
As well as using "light years" to measure distances, astronomers use the "Astronomical Unit" or "AU". 1 AU is defined as the distance between the Sun and the Earth.

Light takes 8 minutes to travel from the Sun to the Earth. The speed of light is 3×10^8 m/s.

How far, in metres, is 1 AU? [4]

Question 6

The diagram below shows the distance in AU from the sun to all the planets as well as to the dwarf planet Pluto.



a) How far in AU is Saturn from the sun? [1]

b) What can you deduce from the diagram about the orbit of Pluto compared to the other planets? [3]

c) Is the "mystery reflector" that caused the TV signals to be reflected back to Earth inside or outside the Solar System? [1]

d) Explain your answer to part c). [3]

Question 7

The following equation may be useful for this question:

Wave speed = (number of waves per second) x (wavelength)

The speed of light waves is 3×10^8 m/s.

The TV signal detected by the Arecebo Radio Telescope was found to consist of waves with a frequency of 50 million waves per second.

What is wavelength of these waves? Suggest a sensible unit. [4]

Question 8

If the speed of light stays the same but the number of waves per second increases, would the wavelength increase or decrease? [1]

Explain your answer? [2]

Question 9

You may remember seeing the Arecebo Radio Telescope in the James Bond movie, GoldenEye. In the finale of the film, James Bond and Natalya Simonova slide down the dish of the Arecibo Telescope.

Describe the energy changes that take place as they move from the lip of the dish towards its centre in as much detail as you can. [3]

