RADLEY

2022 Scholarship Examination Paper

PHYSICS

Time allowed – 30 min

Total marks: 33

PLEASE WRITE IN BLACK INK

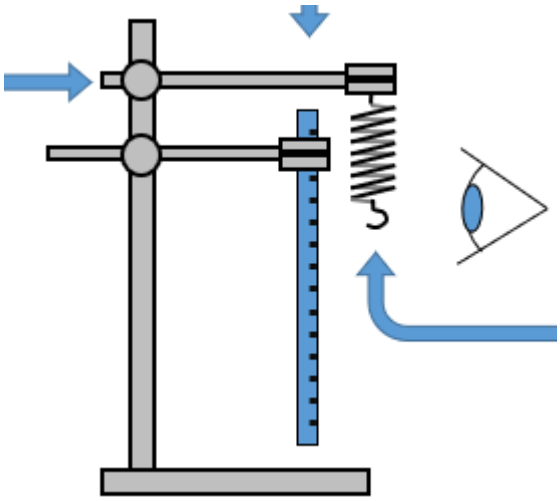
Calculators are not to be used

Total marks available = 33

- Most of the marks are for **showing clear thinking**.
- Your final answers are less important than demonstrating a logical and systematic approach.
- **Use bullet points**
- **Show your working** out at all stages. State any assumptions that you make.
- Where you can, use powers of ten to show very big or very small numbers.
  For example, "1,000,000" can be written: 1.0×10^6

Question 1

Tell me as much as you can about what you can see in this diagram:



[5 marks]

Question 2

When doing an estimation, as is often the case when solving a tough problem in life, there is usually "more than one way to skin a cat" (several different ways to solve a problem).

Make sure you show your reasoning carefully in this question:

How many hairs does the Head of Physics' cat (called Kovu) have?

[5 marks]

Question 3

The James Webb Space Telescope (JWST) is an incredibly exciting next generation telescope that was successfully launched on 25th December 2021. Its mirror is approximately 6.5 m in diameter, much larger than the 2.4 m mirror of the Hubble Space Telescope (HST), and so it has far greater resolution and sensitivity. Whilst HST largely imaged in the visible, JWST will do most of its work in the near-and mid-infrared (NIR and MIR respectively). This will allow it to pick up heavily redshifted light, such as that from the first generation of stars in the very first galaxies

(a) The sun's heat arriving from the JWST is prevented from making the telescope too hot by four spaced panels (a bit like heat loss from a house can be reduced by using double glazing.)
Explain how this reduces heat loss from a warm place to a colder environment.
[4 marks]

(b) Frequency, wavelength and speed are three important properties of radio waves. They are related by the following equation:
Wavelength (in metres) = Wave Speed (in metres per second) ÷ Frequency (in Hertz)

Radio wave signals from Earth to JWST are broadcast at a frequency of 2.0×10^9 Hertz. Radio waves travel at 3.0×10^8 m/s. Calculate the wavelength of the radio wave signals that travel from Earth to the JWST - express your answer in metres
[4 marks]

(c) The amount of light collected by a telescope depends on the area of the telescope's mirror

If the Hubble space telescope collects light from a distant star, 34 photons are collected in the mirror per second.

How many photons per second would the JWST collect per second?
[4 marks]

Question 4

The distance from Earth to the Sun can be accurately calculated by measuring the distance from Earth to Venus when exactly half of Venus is visible as seen from Earth.

The angle between Venus and the Sun as seen from Earth is then measured.

(a) Draw a labelled diagram to show the relative positions of Earth, Venus and the Sun when exactly half of Venus is visible from Earth.
[3 marks]

(b) State the angle between a line drawn from the Sun to Venus and a second line drawn from Earth to Venus. (i.e. the angle between Earth and the Sun as seen from Venus)
[1 mark]

(c) The distance to Venus is measured by accurately timing how long it takes a radar beam to bounce off Venus and return to Earth.

Given that the speed of the radar beam is 2.9979×10^8 m/s and the 'echo' of the radar signal is detected 692.43 s after being transmitted, show that the distance to Venus is around 100×10^6 km.
[2 marks]

(d) Suggest a reason why the distance to the Sun cannot be measured using radar.
[2 marks]

(e) Suggest how the distance from the Earth to the Sun can be determined – what further measurement would need to be made and how can that be used to find the Earth-Sun distance?
[3 marks]