

Key Area 6 - The Expanding Universe

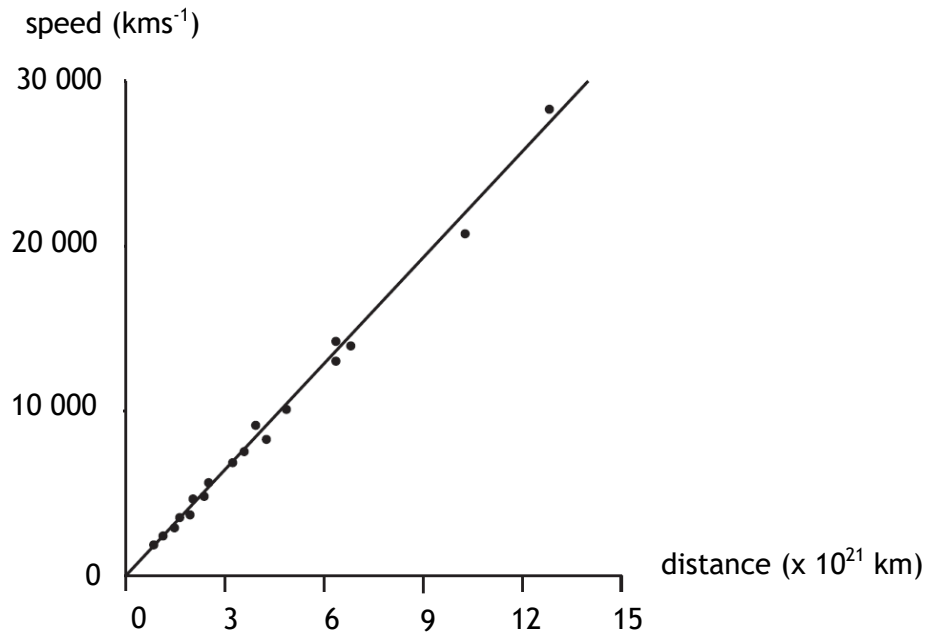
Multiple Choice Questions 1 → 10

1. A galaxy is moving away from Earth at a velocity of $1.20 \times 10^7 \text{ ms}^{-1}$. Light of wavelength 450 nm is emitted from this galaxy.

Calculate the wavelength of light that is detected on the Earth.

- A 425 nm
- B 432 nm
- C 468 nm
- D 475 nm
- E 630 nm

2. Galaxies at different distance from Earth have been found to have different speeds. The graph shows data for some distant galaxies.



A student studies this graph and makes the following statements.

- I The speed of distant galaxies varies inversely with their distance from the Earth.
- II The gradient of the line gives the value of Hubble's constant.
- III The unit for Hubble's constant is s^{-1} .

Identify which of these statements is/are correct.

- A I only
- B II only
- C III only
- D I and II only
- E II and III only

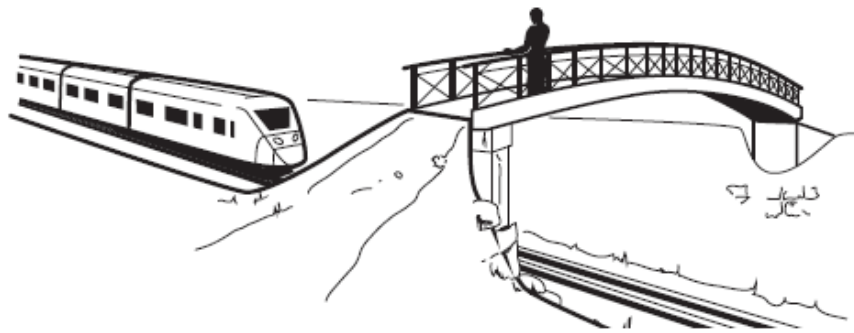
3. An astronomer observes the spectrum of light from a star. The spectrum contains the emission lines for hydrogen.

The astronomer compares this spectrum with the spectrum from a hydrogen lamp. The line which has a wavelength of 656 nm from the lamp is found to be shifted to 663 nm in the spectrum from the star.

Calculate the redshift of the light from this star.

- A 0.011
- B 0.05
- C 0.99
- D 2
- E 94

4. A train is travelling at a constant speed of 16.0 ms^{-1} as it approaches a bridge.

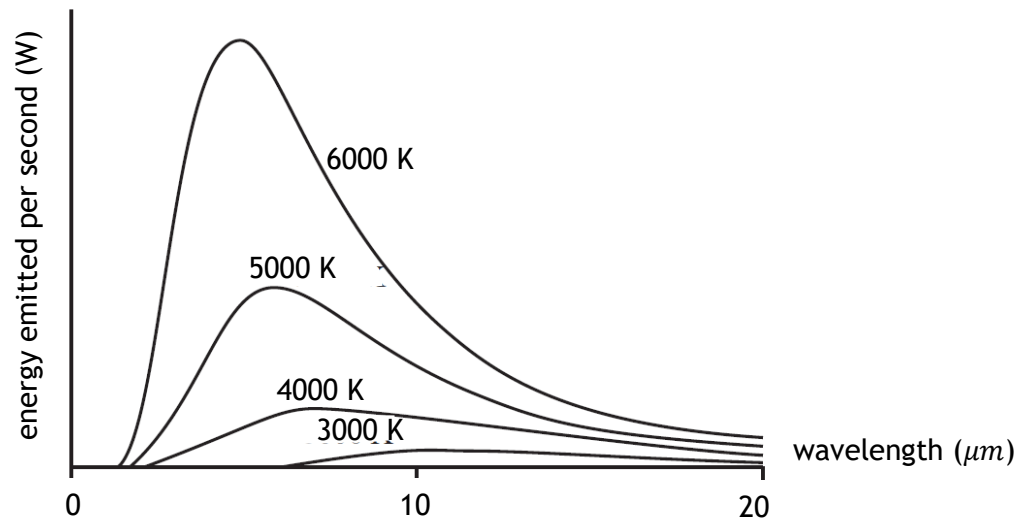


A horn on the train emits sound of frequency 277 Hz. The sound is heard by a person standing on the bridge. The speed of sound in air is 340 ms^{-1} .

Calculate the frequency of the sound heard by the person standing on the bridge.

- A 265 Hz
- B 277 Hz
- C 291 Hz
- D 357 Hz
- E 361 Hz

5. The graph shows how the energy emitted per second from the surface of a hot object varies with the wavelength, λ , of the emitted radiation at different temperatures.



A student makes the following statements based on the information shown in the graph.

- I As the temperature of the object increases, the total energy emitted per second decreases.
- II As the temperature of the object increases, the peak wavelength of the emitted radiation decreases.
- III The frequency of the emitted radiation steadily increases as the emitted energy per second decreases.

Identify which of the following statements is/are correct.

- A I only
 - B II only
 - C III only
 - D I and II only
 - E II and III only
6. Identify which aspect the cooling of the Universe and cosmic microwave background radiation provide evidence for.
- A the photoelectric effect
 - B the Bohr model of the atom
 - C the theory of special relativity
 - D the Big Bang theory
 - E Newton's Universal Law of Gravitation

7. Astronomers use the following relationship to determine the distance, d , to a star.

$$b = \frac{L}{4\pi d^2}$$

For a particular star the following data is recorded:

Apparent brightness, $b = 4.4 \times 10^{-10} \text{ Wm}^{-2}$

Luminosity, $L = 6.1 \times 10^{30} \text{ W}$

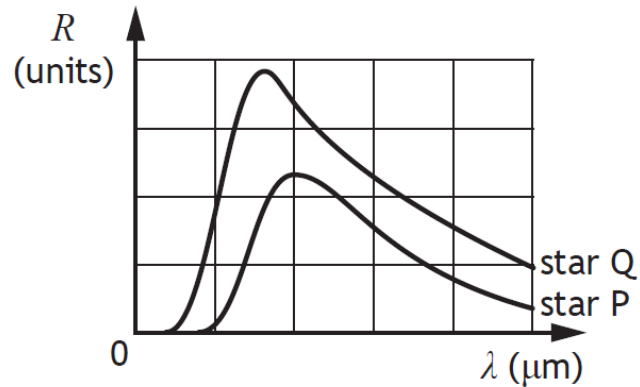
Based on this information, calculate the distance to this star.

- A $3.3 \times 10^{19} \text{ m}$
 - B $1.5 \times 10^{21} \text{ m}$
 - C $3.7 \times 10^{36} \text{ m}$
 - D $1.1 \times 10^{39} \text{ m}$
 - E $3.9 \times 10^{39} \text{ m}$
8. A siren on an ambulance emits a constant frequency of 750 Hz. The ambulance is travelling at a constant speed of 25.0 ms^{-1} towards a stationary observer. The speed of sound in air is 340 ms^{-1} .

Calculate the frequency of sound heard by the observer.

- A 695 Hz
- B 699 Hz
- C 750 Hz
- D 805 Hz
- E 810 Hz

9. The graph shows how the radiation per unit surface area, R , varies with the wavelength, λ , of the emitted radiation for two stars, P and Q.



A student makes the following conclusions based on the information in the graph.

- I star P is hotter than star Q.
- II star P emits more radiation per unit surface area than star Q.
- III the peak intensity of the radiation from star Q is at a shorter wavelength than that from star P.

Identify which of these statements is/are correct.

- A I only
- B II only
- C III only
- D I and II only
- E II and III only

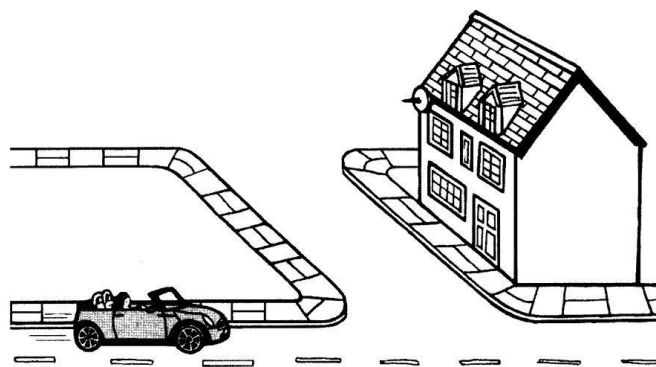
10. A spectral line of sodium is 589 nm, as measured on Earth. The same spectral line is detected from a distance galaxy at 612 nm.

Calculate the distance to this galaxy.

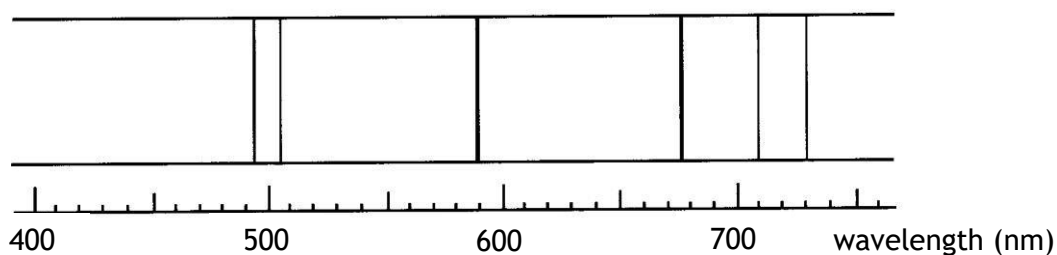
- A 2.99×10^{-28} m
- B 2.69×10^{-11} m
- C 5.66×10^7 m
- D 4.90×10^{24} m
- E 5.09×10^{24} m

Full Response Questions 11 → 13

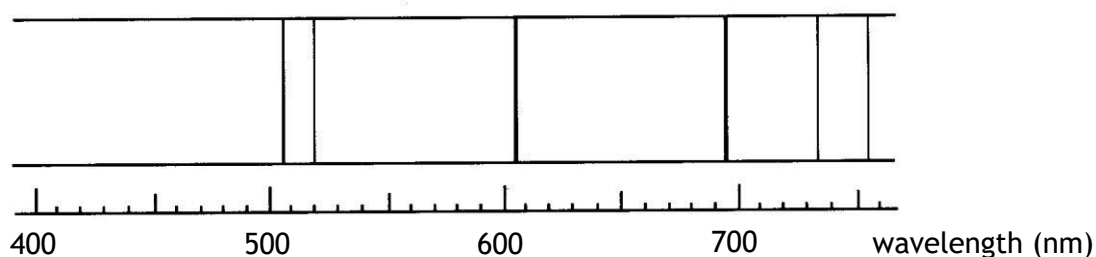
11. A car approaches a building where there is a stationary observer. The car sounds its horn



- (a) The speed of the car is 25.0 ms^{-1} and the frequency of the sound emitted by the horn is 1250 Hz .
- (i) Explain in terms of wavefronts why the sound heard by the observer does not have a frequency of 1250 Hz .
- (ii) Calculate the frequency of the sound from the horn heard by the observer.
- (b) The spectrum of light from most stars contains lines corresponding to helium gas. The diagram below shows the helium spectrum from the Sun.



The diagram below shows the helium spectrum from a distant star.



By comparing these spectra, state what conclusion can be made about the distant star. Justify your answer.

12. In 1929 Edwin Hubble suggested that distant galaxies are moving away (receding) from our own galaxy with velocities that are directly proportional to the distance to the galaxy. This relationship is known as Hubble's Law.

Some of the data collected by Edwin Hubble is given in the table below.

galaxy	distance to galaxy (light years)	velocity of recession (ms ⁻¹)
NGC 221	9.0×10^5	2.0×10^5
NGC 379	2.3×10^7	2.2×10^6
Gemini cluster	1.4×10^8	2.3×10^7

- (a) Using **all** of the data, determine whether or not this data supports Hubble's Law.
- (b) The speed of recession of the galaxies is found from observation of redshift. State what is meant by the term redshift.
13. All stars emit electromagnetic radiation with a range of wavelengths. The peak wavelength of radiation, λ_{peak} , emitted from a star is related to the surface temperature, T, of the star.

The table gives the surface temperatures, in kelvin, of four different stars and the peak wavelength radiated from each star.

Surface temperature of star T (K)	Peak wavelength radiated λ_{peak} (m)
4200	6.90×10^{-7}
5800	5.00×10^{-7}
7900	3.65×10^{-7}
12 000	2.42×10^{-7}

- (a) Use **all** the data in the table to show that the relationship between the surface temperature, T, of a star and the peak wavelength radiated, λ_{peak} , from the star is

$$T = \frac{2.9 \times 10^{-3}}{\lambda_{peak}}$$

- (b) The blue supergiant star Eta Carinae is one of the largest and most luminous stars in our galaxy. It emits radiation with a peak wavelength of 76 nm.

Calculate the surface temperature, in kelvin, of this star.