

Name: _____ Class: _____ Date: _____



Sec 3 Physics

Worksheet 4: EM waves (self-attempt)

Conceptual Questions

1. What colour of the visible spectrum has the longest wavelength? Which has the shortest wavelength?
2. In a boutique store with only fluorescent lighting, a customer insists on taking dresses into the daylight at the doorway to check their colour. Is she reasonable? Explain.
3. Fire engines used to be red. Yellow-green is now the preferred colour. Why?
4. Which EM waves are associated with high-energies? Which ones are the low-energies?
5. Does a microwave photon have a lot of energy? How can our food be “cooked” by microwaves?
6. Can radar cook birds which happen to fly by during its operation?
7. Human beings have a body temperature of around 37°C . What is the dominant EM radiation that our bodies emit?
8. Can the human body produce EM waves other than infrared?
9. Does light travel infinitely fast, or does it have a finite speed?
10. Can we look into the past?
11. Is Earth a bright object in the solar system?
12. There is a rule (Wien’s displacement law) that tells us the type of radiation an object emits depends on its temperature. Cool objects emit radio waves mostly, while very hot objects (e.g. plasma of about 10 million K) emit mostly X-rays. Therefore, by looking at the colour of stars, we can tell how hot the star surfaces are. There are red stars, orange stars, yellow stars, blue stars and white stars. Why are there no green stars?

7 Which of the following statements is true about all electromagnetic waves?

- A** Can be detected by a radio aerial.
- B** Can be detected by photographic film.
- C** Can travel at the same speed in a vacuum.
- D** Can be deflected by magnetic fields.

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8 The wavelength of visible light is approximately

- A** 10^{-3} km
- B** 10^{-6} km
- C** 10^{-9} km
- D** 10^{-12} km

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9 The wavelength of the blue visible light waves is greater than that of

- A** radio waves
- B** X-rays
- C** red light waves
- D** infra-red waves

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10 The Sun heats the Earth by electromagnetic radiation. Which part of the electromagnetic spectrum is responsible for most of this heating?

- A** Radio waves
- B** Infra-red rays
- C** Ultraviolet radiation
- D** X-ray radiation

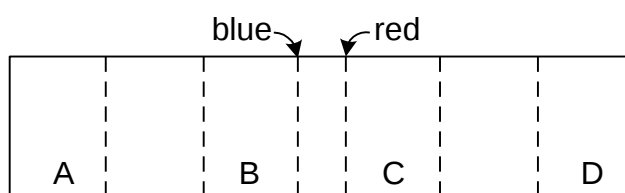
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11 Which one of the following can be quickly detected by a person when it is incident on his skin?

- A** Radio waves
- B** X-rays
- C** Gamma radiation
- D** infra-red rays

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12 The diagram below shows the electromagnetic spectrum, with the blue and red ends of the visible light spectrum marked.

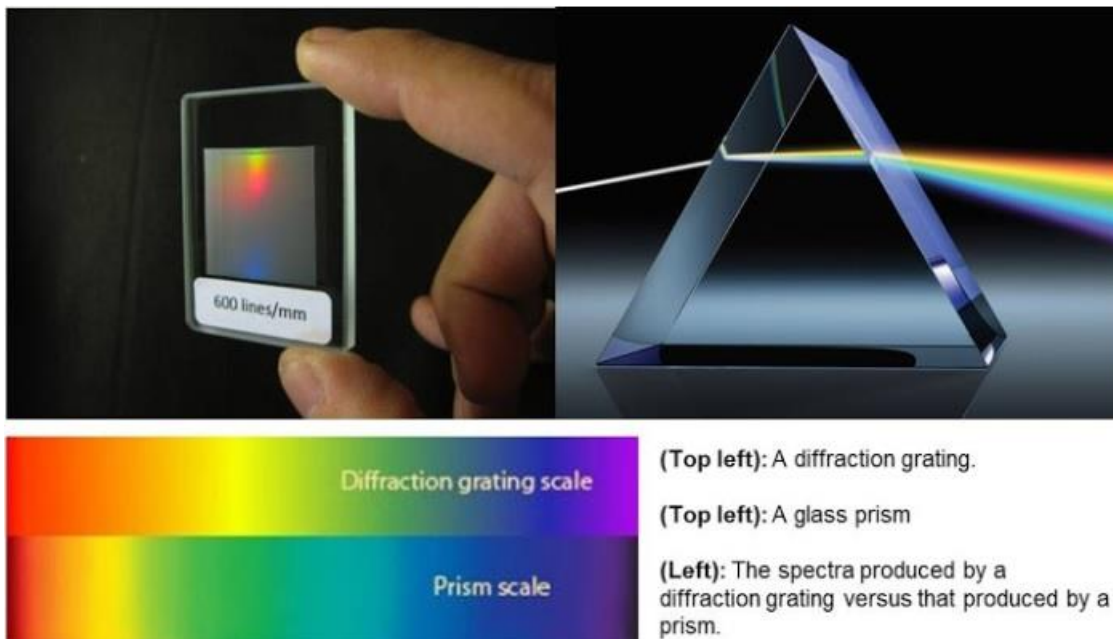


Which one of the sections of the spectrum has the following characteristics?

“Rays of very penetrating short wavelengths that can be detected on photographic film and they come from the nuclei of atoms.”

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- 13 A spectrograph is a tool to study spectra. In modern spectrographs, a diffraction grating is often used to “split” the spectrum rather than using a prism. Which of the following statements give the reasons why diffraction gratings are preferred over prisms?

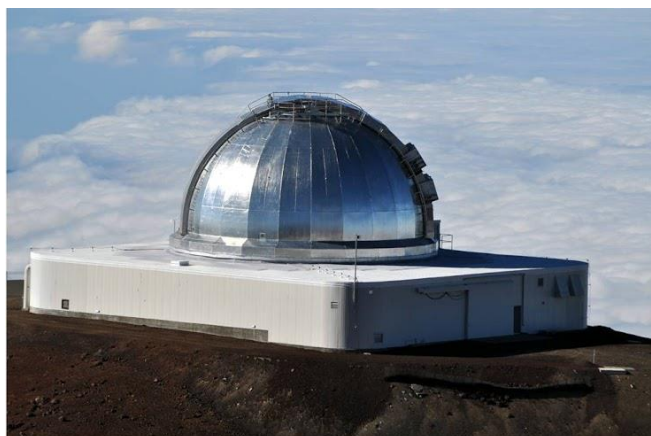


1. A prism does not disperse the colours of the rainbow evenly. Blue and violet portions are spread more than the red part.
 2. Because blue and violet wavelengths must pass through a longer distance in the prism's glass than the red wavelengths, light is absorbed unevenly across the spectrum.
 3. Glass prism is relatively opaque to near-UV, which implies that the violet end is much dimmer.
 4. A glass prism can shatter easily compared to a diffraction grating.
- A** Statement 1 only.
B Statement 1 and 2 only.
C Statement 1, 2 and 3 only.
D All statements are valid.

- 14 The microwave oven has a glass window through which we can observe the food while cooking. Is it safe to view through the glass while the microwave oven is in operation?



- A** Yes, it is safe because the window is covered with a metal screen with small holes.
- B** No, it is not safe because if we can see things inside, then both visible light and microwave can leak out of the oven.
- C** Yes, it is safe because there is a chemical coating that prevents the microwave from leaking out of the oven.
- D** Yes, it is safe because glass is opaque to the microwave.
- 15 Why are infra-red telescope often built on the top of mountains?



(Above): Infra-red telescopes, such as the one shown, are often located on top of mountains.

- A** So that the telescopes will be closer to the heavenly objects which they are observing.
- B** To reduce the humidity as much as possible.
- C** No one wants bird droppings on their telescope.
- D** So that there are no trees to block their view.

SECTION B SHORT STRUCTURED QUESTIONS

- 1a) Complete the gaps in the diagram of the electromagnetic spectrum. [2]

RADIOWAVES						GAMMA
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- b) State two properties of ultra-violet radiation which differ those of infra-red radiation. [2]

- c) State two properties which are common to all forms of electromagnetic radiation. [2]

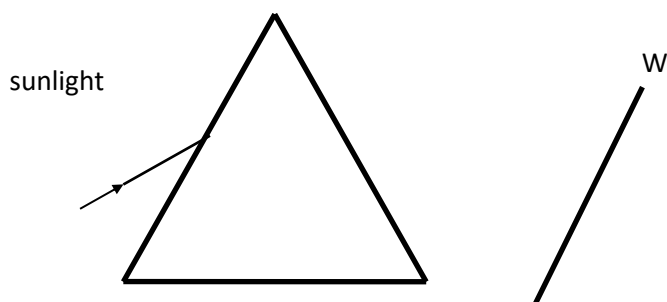
- 2 Very short-wavelength radio waves can be used to determine the Moon's distance from the Earth by measuring the time taken for radio waves to travel from the Earth to the Moon and back again.

Calculate the delay between the transmission and reception of the signal when the Moon is 3.9×10^8 m from the Earth given that the speed of electromagnetic waves is 3.0×10^8 ms⁻¹.

[2]

- 3 The figure shows a ray of sunlight incident upon a glass prism such that a spectrum is produced on the screen **W**.

- a) Continue the ray to illustrate how the spectrum is formed on the white screen at **W**. Mark the violet end of the spectrum **V** and the red end **R**. [2]



- b) The refractive index of the glass is 1.5 for red light. State whether the refractive index of glass for violet light is greater than, equal to, or less than 1.5. Explain how you deduced your answer. [3]

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The glass prism transmits some ultraviolet and some infrared radiations.

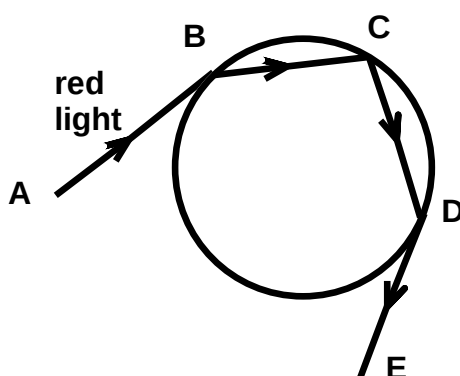
- c) On the same diagram above, mark with **U** the region of the screen at which you would detect UV radiation and with an **I** the region at which you would detect IR radiation. [1]

- d) State one method by which you could detect the presence of UV radiation. [1]

- e) State whether the frequency of UV is greater than, equal to, or less than that of the IR radiation. [1]

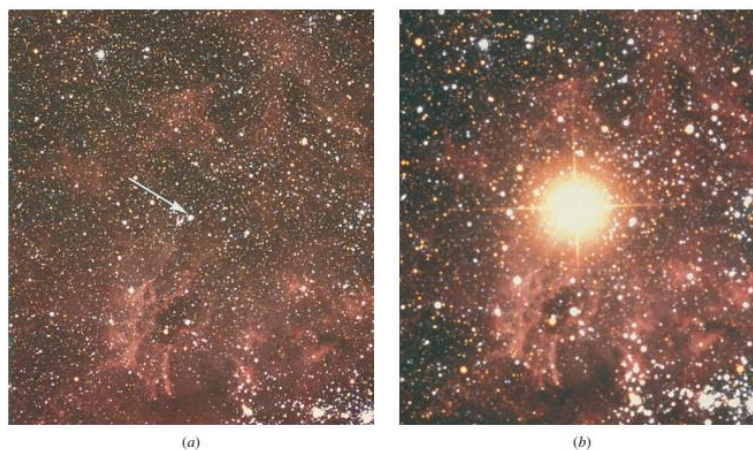
- 4 In the figure, **ABCDE** shows the path of a ray of red light through a raindrop. Assume that a ray of blue light is also incident along path **AB**.

- a) Complete the diagram showing a possible path for the blue light through the raindrop. [2]



- b) Explain why the paths followed by the red and blue light are different. [3]

- 5 Far Light is Old Light.** A supernova is an explosion that occurs at the death of certain stars. For a few days after the supernova, the emitted light's intensity can become a billion times greater than that of our own Sun. After several years, however, the intensity returns to zero. Supernovae are rare events in the universe; only six have been observed in our galaxy within the past 400 years. A supernova that occurs in a neighbouring galaxy approximately 1.66×10^{21} m away was recorded in 1987.



(a) Before the supernova

(b) After the supernova

- (a)** How many years before 1987 did the supernova occur at the neighbouring galaxy? [2]

- (b)** Astronomers often say that the further the event is from Earth, the further in time we see. Can you elaborate on this statement?

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- ** (c)** The earliest moment in time is the Big Bang itself. If we look far enough, can we see the Big Bang ($t = 0$) ? Justify your answer.

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**** (d)** If we cannot see the Big Bang, how far back into the past can we see?

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Global Position System (GPS) satellites transmit radio signals used by receivers on the Earth to determine position with very high precision. The operating principle is that a receiver gets signals simultaneously from several different satellites (typically at least four) and uses them to “triangulate” its position. This method relies on precise knowledge of the time it takes for a satellite signal to reach the receiving position. Until a few years ago, the US government intentionally degraded the timing information so that it had an uncertainty of about 350 ns. Based on the timing error, estimate the precision in metres to which the position can be determined. [2]