Comparison between NEW and OLD syllabuses

In the NEW Physics syllabus, some topics are removed and some are newly added. Moreover, the syllabus is divided into two parts: **core** and **extension**. Some difficult topics are grouped under the extension part and they will only be asked in Section B of both Papers 1 and 2.

(a) Topics removed from and added to the syllabus

The following table shows the topics that are removed from and added to the syllabus. Questions involving the removed topics in past examination papers are now out of the syllabus, while the newly added topics are allocated in both the core and extension parts. Students should pay more attention to the new topics during revision.

Section	Topics removed	Topics added
Optics	• Reflection by curved mirrors • Optical instruments: magnifying glass, microscope, telescope, human eye, camera	—
Heat	• Gas laws, Kinetic theory	• Transfer process of heat (conduction, convection and radiation)
Mechanics	• Pressure as force per unit area • Moment produced by a force • Machine	—
Waves	• Standing (stationary) waves • Use of stroboscope	• Using the unit decibel to measure the sound intensity level • Noise pollution and acoustic protection
Electricity and Magnetism	• CRO, electronic devices, logic gates • Charging by using an E.H.T power supply	—
Atomic Physics	• α-particle scattering experiment	• Using sievert as a unit to measure radiation dosage • Nuclear fusion and solar energy

7 Light

Concept Map

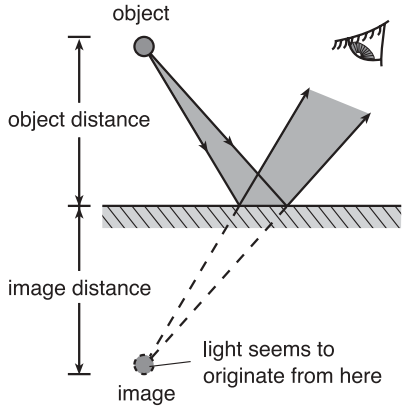
Light

Wave nature of light

- Light is a part of the electromagnetic spectrum.
- Light travels at 3×10^8 m s^{-1} in a vacuum.
- Light is an example of a transverse wave.
- The colour spectrum of visible light ranges from red (700 nm) to violet (400 nm).
- The electromagnetic spectrum includes the following members (arranged in ascending order of wavelength):
  - Gamma rays (γ-rays)
  - X-rays
  - Ultraviolet radiation
  - Visible light (from violet to red)
  - Infrared radiation
  - Microwaves
  - Radio waves
- Electromagnetic waves are widely used in everyday life for radiotherapy, medical diagnosis, sterilization, telecommunications and so on.
- The diffraction of light and interference of light are evidence for the wave nature of light.

Reflection of light

- Laws of reflection
  - Angle of incidence = angle of reflection
  - Normal, incident ray and reflected ray all lie on the same plane.
- Characteristics of images formed by a plane mirror
  - Image distance = object distance
  - Image formed is upright, laterally inverted and virtual.
- Graphical construction of image formation by a plane mirror:
  - Locate the position of the image using the fact that object distance equals image distance.
  - Then construct the reflected rays. Use solid lines with an arrow to represent light rays and dotted lines to indicate the imaginary light rays behind the mirror.



- Applications of plane mirrors
  - Rear view mirrors
  - Periscopes
  - Interior design
  - Curtain walls of skyscrapers

Refraction of light

Refraction at a boundary

- Refraction of light refers to the change in the speed of light at the boundary of two media.
- Laws of refraction
  - Normal, incident ray and refracted ray all lie on the same plane.
- Snell's law

$$n_X = \frac{\sin\theta_A}{\sin\theta_X}$$

where
θ_A is the angle between the normal and the light ray in air;
θ_X is the angle between the normal and the light ray in medium X;
n_X is the refractive index of medium X.

- $n_X = \dfrac{\text{speed of light in a vacuum}}{\text{speed of light in medium } X}$

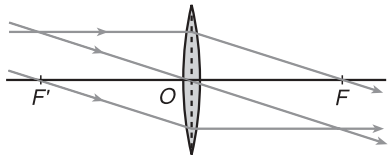
Total internal reflection Extension

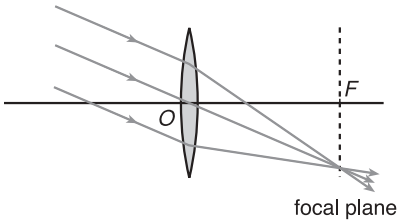
- Necessary conditions for total internal reflection:
  - light passes from an optically denser medium to an optically less dense medium; and
  - angle of incidence is larger than the critical angle c.
- $c = \sin^{-1}\left(\dfrac{1}{n}\right)$
- Phenomena and applications of total internal reflection
  - Rainbows
    Both dispersion of white light and total internal reflection occur in the formation of rainbows.
  - Optical fibres
    Light signals are guided through the fibre as a result of total internal reflection.

Refraction by a lens

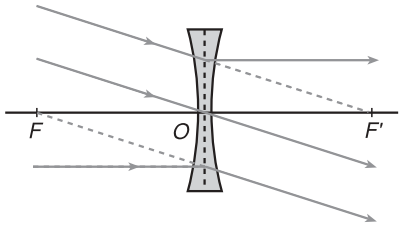
Construction rules

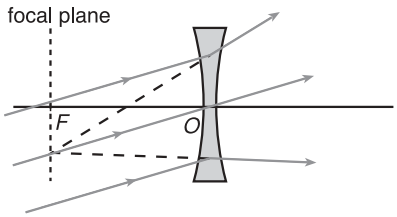
- For converging lenses:





- For diverging lenses:





7.1 Wave nature of light

Learning Focus

- Understand that light is an example of a transverse wave.
- Understand that light is a part of the electromagnetic spectrum.
- Know the range of the wavelengths for visible light.
- Recognize the relative positions of visible light and the other parts of the electromagnetic spectrum.
- Know the speed of light and other electromagnetic waves in a vacuum.

A. Light as an example of a transverse wave

- Light is a transverse wave.
- Light is one type of electromagnetic wave（電磁波）. An electromagnetic wave (EM wave) is a series of oscillations of the electric and magnetic fields.
- EM waves (including light) can travel through a vacuum（真空）.

B. Visible light

- White light can be resolved into a colour spectrum. This means that white light is composed of light of different colours, which range from red to violet.
- The wavelength of visible light（可見光）varies between 700 nm (red) and 400 nm (violet), where 1 nm is equal to 1×10^{-9} m.

Reminder

Students have to memorize the range of wavelengths of visible light.

C. The electromagnetic spectrum

- *Electromagnetic waves* are waves of oscillating electric and magnetic fields, which are often categorized into seven types: **gamma rays (γ-rays)**（伽瑪射線）, **X-rays**（X 射線）, **ultraviolet radiation**（紫外輻射）, **visible light**, **infrared radiation**（紅外輻射）, **microwaves**（微波）and **radio waves**（無線電波）.
- The range of wavelengths over which electromagnetic waves extend is called the **electromagnetic spectrum**（電磁波譜）.
- All electromagnetic waves can travel through a vacuum.
- All electromagnetic waves travel with the same speed in a vacuum. The speed of light (and electromagnetic waves) in a vacuum c is 3×10^{8} m s^{-1}.
- The speed of electromagnetic waves in other media is less than c.

Reminder

All electromagnetic waves have common wave properties.

Practice

Paper I Conventional Questions

Section A

(Given: speed of light in vacuum = 3×10^8 m s^{-1})

1. Both X-rays and gamma rays are hazardous to humans. Living Physics

   (a) What is the typical wavelength of X-rays? Hence find their frequency. (2 marks)

   (b) Although X-rays and gamma rays are hazardous, there still have some useful everyday applications. State and describe one application of each of them. Hint 1 (4 marks)

2. Visible light is a part of the electromagnetic spectrum.

   (a) What is the range of wavelengths for visible light? (2 marks)

   (b) Describe a simple experiment to show one of the vital wave natures of visible light. Hint 2 (3 marks)

3. An arrow is placed in front of a plane mirror. Peter looks at the mirror to see the image formed (see Figure 7.71).

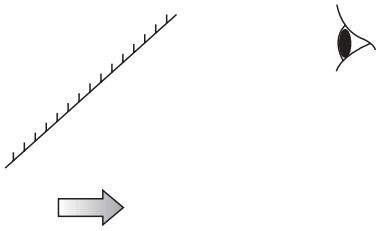


Figure 7.71

   (a) Complete Figure 7.71 to show how the image of the arrow is formed. Show clearly how the light from the head and tail of the arrow is reflected to Peter's eye. (3 marks)

   (b) State the properties of the image formed. (2 marks)

   (c) What will happen to the position and size of the image if Peter walks slowly away from the mirror? Hint 3 (1 mark)

4. A rainbow is a colour spectrum produced by refraction of light in small water droplets which are suspended in the air after rain.

   (a) Explain how white sunlight is refracted into a colour spectrum in a water droplet. Hint 4 (4 marks)

   (b) Draw a ray diagram to show the dispersion of sunlight by a glass prism. (3 marks)

Paper II Multiple-choice Questions

Section A

1. When two sources of red light interfere constructively, the resultant light will be Hint 26

   A. red light.
   B. orange light.
   C. green light.
   D. violet light.

2. The frequency of an electromagnetic wave is 3×10^{10} Hz. The wave is

   A. an X-ray.
   B. a gamma ray.
   C. a microwave.
   D. ultraviolet radiation.

3. Which of the following statements about visible light are correct? Hint 27

   (1) It is a transverse wave.
   (2) It can travel through a vacuum.
   (3) It diffracts when it passes through a narrow slit.

   A. (3) only
   B. (1) and (2) only
   C. (2) and (3) only
   D. (1), (2) and (3)

4. Which of the following electromagnetic waves contained in sunlight induces the production of vitamin D in our skin? Hint 28 Living Physics

   A. ultraviolet radiation
   B. infrared radiation
   C. violet light
   D. X-rays

5. Which of the following electromagnetic waves may cause skin cancer? Living Physics

   A. infrared radiation
   B. ultrasound
   C. ultraviolet radiation
   D. visible light

6. Arrange the following electromagnetic waves in ascending order of their wavelengths.

   (1) radio waves
   (2) ultraviolet radiation
   (3) infrared radiation

   A. (1), (2), (3)
   B. (2), (3), (1)
   C. (3), (1), (2)
   D. (1), (3), (2)

7. A light ray strikes a plane mirror at a point *P*. If the mirror is rotated clockwise by 20° as shown in Figure 7.86, what will happen to the angle between the incident ray and the reflected ray? Hint 29

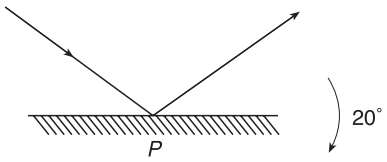


Figure 7.86

   A. increases by 20°
   B. increases by 40°
   C. decreases by 20°
   D. decreases by 40°

8. A light ray passes from air into a perspex block at an angle of incidence of 40°. The ray is deflected by 17.8° towards the normal of the boundary. Find the refractive index of perspex. Hint 30

   A. 1.40
   B. 1.50
   C. 1.70
   D. 2.10

- Table 8.2 summarises the properties of sound and light for comparison.

	Sound waves	Light waves
Wave nature	• Both of them demonstrate reflection, refraction, diffraction and interference. • Both of them obey the equation $v = f\lambda$, where v represents their respective speeds.	
Direction of disturbance (vibration)	Longitudinal wave (vibration is parallel to the travelling direction of the wave.)	Transverse wave (vibration is perpendicular to the travelling direction of the wave.)
Medium	It requires a medium for propagation. It cannot travel through a vacuum.	It can travel through a vacuum or any transparent medium.
Speed in air	~ 340 m s^{-1} in air $v_{solid} > v_{liquid} > v_{gas}$	3×10^8 m s^{-1} in a vacuum or air $v_{vacuum} > v_{gas} > v_{liquid} > v_{solid}$
Frequency	Audible sound for humans: 20 – 20 000 Hz	Visible light: 10^{14} Hz
Wavelength	Audible sound: 10^{-2} m – 10^{1} m	Visible light: 10^{-7} m

Table 8.2

B. Audible sound and ultrasound

(a) Audible sound

The range of audible sound is frequently asked about in the HKCEE multiple-choice questions.

- Humans can only hear sound within the frequency range 20 Hz to 20 000 Hz.
- Sound waves with frequencies lower than 20 Hz are called infrasound or infrasonic waves（超低頻聲波）.
- Sound waves with frequencies above 20 000 Hz are called **ultrasound** or **ultrasonic waves**（超聲波）.

(b) Properties of ultrasonic waves Extension

- Ultrasound is a sound wave with a frequency above 20 000 Hz. Humans cannot hear this kind of sound wave but some animals can, for example dogs, dolphins, bats, etc.
- Ultrasonic waves have all the wave properties of audible sound waves. Their speed in air is equal to that of audible sound waves.

(c) Applications of ultrasonic waves Extension

Living Physics

(i) Sonar

- Sonar（聲納）is a system which uses ultrasonic waves to detect obstacles under water.
- Sonar is commonly used in ships to measure water depth, in fishing boats to locate shoals of fish, and in warships to locate submarines, as well as in cars in order to park safely (see Figure 8.3).

Figure 8.3

Glossary

audible sound	可聽聲音	microphone	微音器
cathode ray oscilloscope (CRO)	示波器	musical note	樂音
		noise	噪音
decibel	分貝	pitch	音調
echo	回聲	sonar	聲納
flaw	裂縫	sound intensity level	聲強級
fundamental	基音	sound quality	音質
fundamental frequency	基頻	threshold of hearing	聽覺閾
		ultrasonic scanning	超聲波掃描
harmonics	諧音	ultrasound / ultrasonic wave	超聲波
loudness	響度		

Important Formulae

- $v = f\lambda$
- The wave velocity v of sound can be found from the time elapsed Δt of an echo reflected by an obstacle at a distance d away:

$$v = \frac{2d}{\Delta t}$$

Examination Question Analysis

Topics	Conventional Questions (Year)	Multiple-choice Questions (Year)
Wave nature of sound, reflection, refraction, diffraction and interference	00(9c), 02(5), 03(5)	95(25), 03(29)
Comparison of sound and light Extension	01(6a, b)	95(43), 97(22), 99(25, 45), 01(22), 04(26)
Audible sound and properties of ultrasonic waves Extension	–	92(23, 43), 93(28), 95(26), 98(28), 99(24), 01(22)
Applications of ultrasonic waves Extension	03(7)	94(23), 01(24), 02(28)
Musical notes and noise Pitch, loudness and sound quality Extension	96(4b)	93(27), 00(28), 02(29)
* **Sound intensity level - decibels** Extension	–	–

Note

** Topics added to the new syllabus*

E. Simple circuits

You may follow the following steps to solve simple circuits:

1. Always simplify the circuit as much as possible, for example by combinating cells and resistors, redrawing the circuit diagram where necessary.
2. Find the potential difference across each device and the current flowing through each device.

Students need to practise the skills of solving simple circuits, and they are demonstrated in the following examples.

Guided Example 5

In the circuit in Figure 9.23, 1.2 A of current passes through the 8 Ω resistor.

(a) Find the voltage of the cell.

(b) Find the current delivered by the cell.

(c) What is the potential difference across the 2 Ω resistor?

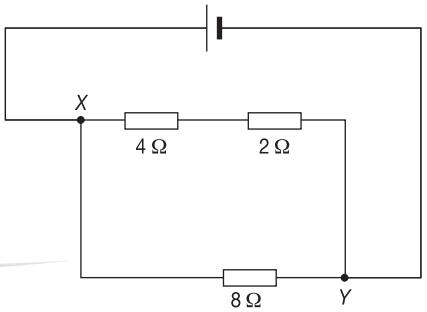


Figure 9.23

Suggested Answer

(a) Voltage of the cell = $V_{XY} = IR$
$= 1.2 \times 8 = 9.6$ V

(b)

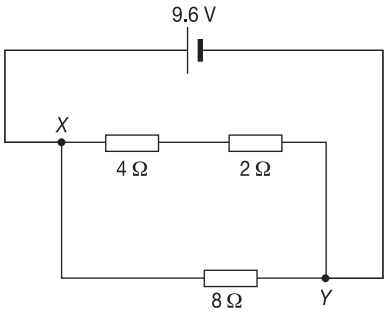


Figure 9.24(a)

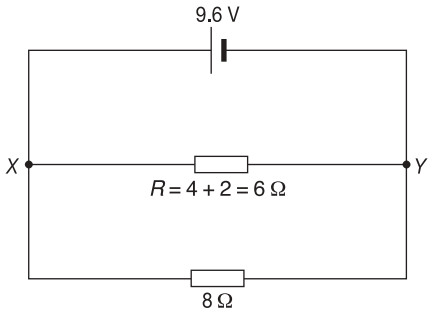


Figure 9.24(b)

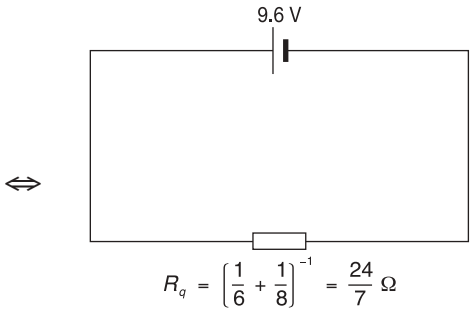


Figure 9.24(c)

Reminder

Combine the two resistors in series into one equivalent resistor. Then this resistor is in parallel with the 8 Ω resistor.

Current delivered by the battery $= \dfrac{E}{R_q} = \dfrac{9.6}{\frac{24}{7}} = 2.8$ A

(c) Current flowing through the 2 Ω resistors = 2.8 – 1.2 = 1.6 A
Potential difference across the 2 Ω resistor = 1.6 × 2 = 3.2 V

Demonstration

Paper I Conventional Questions

Section A

1. (a) The body of a vehicle will carry a static charge after a long journey. Describe how the body becomes charged. (2 marks)

   (b) Petrol trucks usually trail an iron chain along the ground. Explain the importance of such a metal chain. Living Physics (3 marks)

Guidelines

Petrol is extremely inflammable. A spark near petrol can cause a fire or an explosion.

Suggested Answer

(a) When the vehicle moves, its body is charged by friction between itself and air molecules. 1
Since the car is insulated from the ground by its rubber tyres, the static charges accumulate. 1

(b) The static charge flows to the ground through the iron chain so that the truck is earthed. 1
If the truck carries a static charge, sparks may result. 1
A spark may cause an explosion or a fire when there are inflammable gases. 1

2.

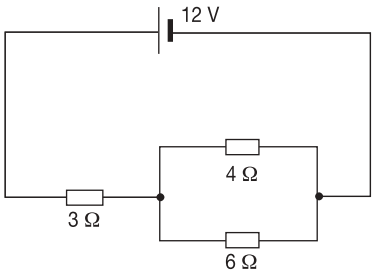


Figure 9.46

Three resistors are connected to a 12 V battery as shown above.

(a) Find the current delivered by the battery. (2 marks)

(b) Describe the energy change in
   (i) the battery, and (1 mark)
   (ii) the 3 Ω resistor. (1 mark)

(c) Find the power dissipated by the 4 Ω resistor. (3 marks)

Guidelines

When dealing with this kind of question, students should always calculate the equivalent resistance first.

9. Read the following passage about magnetically levitated trains and answer the questions that follow:

Extension Living Physics

Magnetically levitated trains

Figure 10.68

Magnetically levitated (MAGLEV) trains（磁浮火車）are considered to be important future travelling machines. The idea of MAGLEV transportation has been in existence since the early 1900s. The benefits of eliminating friction between the wheel and the rail to obtain higher speeds and lower maintenance costs has great appeal. The basic idea of a MAGLEV train is to levitate it with magnetic fields so that there is no physical contact between the train and the rails.

For comparison, 'bullet' trains（子彈火車）in Japan have a maximum speed of about 250-300 km / h while a MAGLEV train under development has reached a speed of 411 km / hr. The MAGLEV train uses powerful onboard superconducting electromagnets with zero electrical resistance to support the train above the rails.

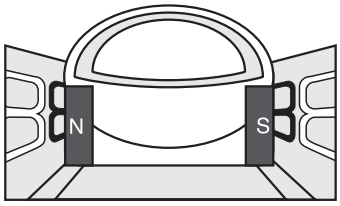


Figure 10.69(a)

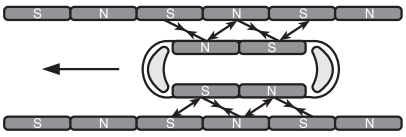


Figure 10.69(b)

The walls along the track contain a continuous series of vertical coils of ordinary wire. As the train passes each coil, the superconducting magnet on the train induces a current in these coils and makes them electromagnets. The electromagnets on the train and outside produce forces that levitate the train and keep it centred above the rails. In addition, electric current flowing through coils outside the train propels the train forward, as shown in Figure 10.69.

(a) What is the major advantage of using superconductors in making the electromagnets? (1 mark)

(b) Explain why the motion of the superconducting magnet on the train induces a current in the coils on the wall. (2 marks)

(c) Give two advantages of magnetically levitated trains over ordinary trains. Hint 8 (2 marks)

- By measuring the percentage of carbon-14 left, we can date ancient remains (for example, the fossil shown in Figure 11.11).

Figure 11.11

Reminder

Carbon is a common element found in living organisms, this method can only be used in dating substances that were once part of a living organism.

(b) The choice of radioactive substance for different applications

Application	Half-life	Reason
Tracer（醫療用示蹤劑）	short (hours or days)	To minimize the side effects on human bodies or the environment.
Sterilization and radiotherapy	long (years)	The radioactivity remains almost constant over a long period of time. The source does not need to be replaced very often.
Gauge（測量計）	long (years)	The radioactivity is almost constant over a long period of time, so that any change in measurement is due solely to the variation in thickness of the specimen being monitored.

Table 11.4

Daily Life Example 1 Living Physics

(a) Compare the ionizing power of alpha and gamma radiation. State and explain the difference.

(b) In a smoke detector shown in Figure 11.12, an α source is installed 4 cm from a radiation detector. Explain briefly how the detector works.

Figure 11.12

Reminder

Ionization is the removal of electrons from an atom or a molecule.

Suggested Answer

(a) α radiation has a higher ionizing power than γ radiation.
This is because α particles are heavy and charged. α particles can interact with other molecules more easily.

(b) α particles interact with smoke particles, hence most of the particles cannot get through the smoke and this results in a drop in current when smoke is present.

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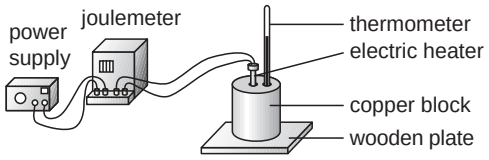
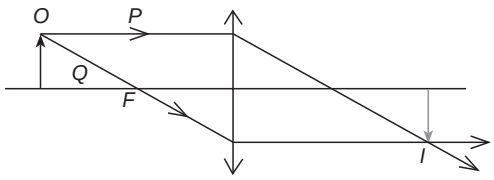
Question Commands

Paper I Conventional Questions

	Question commands	Examples	Tips
1.	Find the ...	1. Find the weight of a man of mass 65 kg. (1 mark) Ans: $W = mg = 65 \times 10 = 650$ N (1A) 2. A car of mass 1200 kg moving at 20 m s^{-1} is brought to stop uniformly by a 800 N friction. Find the braking distance. (3 marks) Ans: Work against friction = change in K.E. or $F \times s = \frac{1}{2}mv^2$ (1M) $800\ s = \frac{1}{2} \times 1200 \times 20^2$ (1M) $s = 300$ m (1A)	• The exact numerical answer is expected. • 1 mark question: a correct answer scores the mark • 2 marks question: 1 mark for the correct formula used and 1 mark for the answer* • 3 marks question: 1 mark for the correct formula or law applied, 1 mark for correct substitution of numerical values and 1 mark for the answer* * If the answer is correct, all the 'M' marks will be granted.
2.	Draw a diagram ...	Draw a diagram to show the experimental setup for the measurement of the specific heat capacity of copper. Ans:  	• The diagram should be labelled properly. Wrong spelling will score no mark. • If possible, use standard equipment/apparatus in the diagram.
3.	Complete the diagram ...	Complete the given diagram by adding the refracted rays of the incident rays *P* and *Q*. Hence locate the image formed. Ans:  	• Add lines, shapes or apparatus to the given diagram.