# 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<br>• 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<br>• Moment produced by a force<br>• Machine | — |
| Waves | • Standing (stationary) waves<br>• Use of stroboscope | • Using the unit decibel to measure the sound intensity level<br>• Noise pollution and acoustic protection |
| Electricity and Magnetism | • CRO, electronic devices, logic gates<br>• Charging by using an E.H.T power supply | — |
| Atomic Physics | • $\alpha$-particle scattering experiment | • Using sievert as a unit to measure radiation dosage<br>• 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 $3 \times 10^8$ 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 ($\gamma$-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
$\theta_A$ is the angle between the normal and the light ray in air;
$\theta_X$ is the angle between the normal and the light ray in medium $X$;
$n_X$ is the refractive index of medium $X$.

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

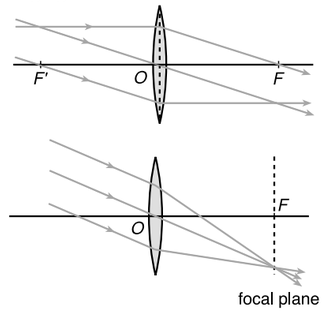
#### Total internal reflection Extension

- 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.

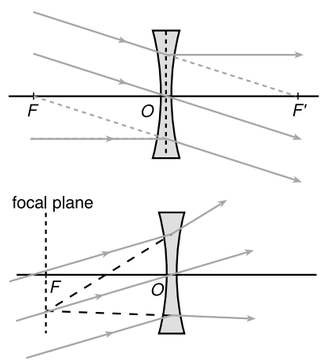
#### Refraction by a lens

**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.
- Recognize that diffraction and interference are evidence for the wave nature of light.

## 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 $1 \times 10^{-9}$ 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 ($\gamma$-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 $3 \times 10^{8}$ 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 = $3 \times 10^8$ 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 daily 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. 

   Figure 7.71

   A compact fluorescent light bulb is often referred as an energy saving lamp（慳電膽）. Such a bulb of 20 W is as bright as a 100 W traditional filament bulb. Other than reducing your electricity bill, using this kind of bulb is also environmentally friendly. So many public areas are lighted by this kind of lamp.

   (a) Compare the electromagnetic waves emitted by a compact fluorescent bulb to that emitted by a filament bulb. Hence explain why a 20 W fluorescent bulb is as bright as a 100 W filament bulb. Hint 3 (2 marks)

   (b) Why it is environmentally friendly using fluorescent bulbs? (2 marks)

4. An arrow is placed in front of a plane mirror. Peter looks at the mirror to see the image formed (see Figure 7.72).

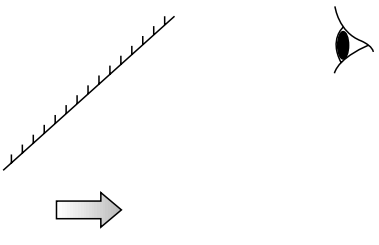


Figure 7.72

26. Read the following passage about Bluetooth communication and answer the questions that follow. Living Physics

## Bluetooth communication


Figure 7.87

*Bluetooth is a technology that enables short-ranged wireless communication between computers, phones and other devices. Bluetooth uses low power radiowaves of typical frequency 2.4 Gigahertz with a working range of about 10 metres. In most countries, uses of this range of electromagnetic frequencies are license-free.*

*Nowadays, Bluetooth are implemented in most mobile phones, handheld computers, laptops, printers, handheld PDAs (personal digital assistants), as well as in all sorts of products. To make use of Bluetooth communication, manufacturers of the electronic devices need to follow a series of standard, and use a common system for data communication. This enables the transmission of data between two Bluetooth devices from different manufacturers.*

(a) What is the typical wavelength of radiowave used in Bluetooth? (2 marks)

(b) A students suggests that the short working range of Bluetooth is due to the short wavelength of the radiowave. Do you agree? Explain briefly. Extension Hint 28 (3 marks)

(c) Suggest two advantages of using low power radiowave for communication (2 marks)

27. Read the following passage about Global Positioning System and answer the questions that follow. Living Physics

## Global Positioning System

*Global Positioning System (GPS) is a nagviation tool which is funded and controlled by the U.S. Department of Defense. Nowadays, ships and airplanes can locate themselves on Earth easily by this system. The system consists of over 20 satellites orbiting around the Earth (see Figure 7.88). They continuously transmit signals to the receivers on Earth with EM waves of about 1575.42 MHz.*

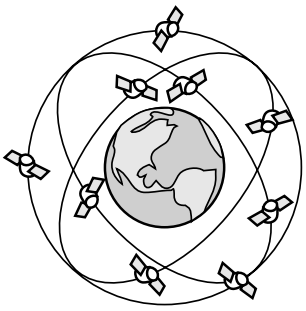


Figure 7.88

*The satellites are orbiting at an altitude of approximately 20,200 kilometers. They are arranged so that at least six satellites are always within line of sight from almost anywhere on Earth. A receiver collect signals from six satellites at a certain moment. By comparing these signals with a computing circuit, location of the receiver can be calculated.*

# 8.1 Wave nature of sound

## Learning Focus

- Study the wave nature of sound.
- Understand that sound waves are longitudinal waves.
- Recognize that sound waves need a medium to transmit.
- Compare the properties of sound waves with those of light waves. Extension
- Distinguish between audible sound and ultrasound.
- Study the properties of ultrasound and its applications. Extension

## A. The wave nature of sound

### (a) Sound is a longitudinal wave

- The direction of vibration of air molecules is parallel to the direction of sound propagation.
- The vibration of the molecules is parallel to the direction of travel of the wave. The to-and-fro motion of the paper cone of an operating loudspeaker demonstrates this.
- Compressions and rarefactions are found in sound (longitudinal waves) rather than the crests and troughs of light (transverse waves), as shown in Figure 8.1. The distance between two adjacent centres of compression is the wavelength of the sound.

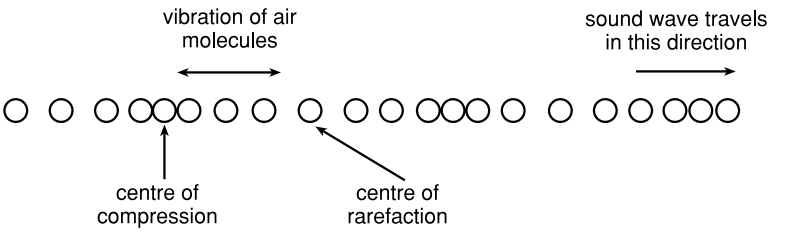



Figure 8.1

**Reminder**

Students may be required in the HKCEE to describe a simple experiment which shows that sound is a longitudinal wave.

### (b) The speed of sound waves

- Sound waves can only travel when there is a medium. They cannot travel through a vacuum.
- Sound waves travel with different speeds in different media.
- In general, the speed of sound in a solid is greater than the speed of sound in a liquid, which is in turn greater than the speed of sound in a gas.
- In the same medium, sound waves of different frequencies travel with the same speed.

**Reminder**

Students should note that sound travels faster in a denser medium, while light behaves in exactly the opposite way.

## Glossary

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

## Important Formulae

- $v = f\lambda$
- The wave velocity $v$ of sound can be found from the time elapsed $\Delta t$ 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), 05(6), 07(6a,bi,10) | 95(25), 03(29), 05(13), 06(17, 18, 20, 33), 07(37, 38, 39) |
| **Comparison of sound and light** Extension | 01(6a, b), 07(6bii) | 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), 07(36) |
| **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), 05(38), 06(34) |
| * **Sound intensity level - decibels** Extension | – | 05(37) |

**Note**

* *Topics added to the new syllabus*

# A. Electric current

- An **electric current**（電流） is a flow of electric charges.
- The magnitude of a current is the quantity of charges passing through a point per unit of time, i.e.,

$$\text{current} = \frac{\text{electric charge}}{\text{time}} \quad \text{or} \quad I = \frac{Q}{t}.$$

- The unit of electric current is the **ampere**（安培）, A. A current of 1 A means that 1 C of charge flows through a point in one second.
- The direction of electric current is taken as being in the opposite direction to that of the flow of electrons. A flow of electrons to the left is equivalent to a current flowing to the right.
- The current flowing through any point in the circuit can be measured by inserting an **ammeter** ( 安培計 , see Figure 9.9) into the circuit, as shown in Figure 9.10.

Figure 9.9

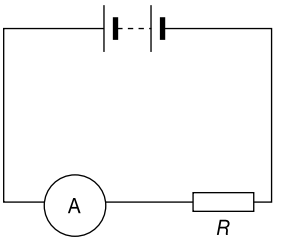



Figure 9.10

- A current flowing in only one direction is a direct current (d.c., 直流電 ).

# B. Electrical energy and electric potential

## (a) Voltage

- Electric charges gain electrical energy from a cell (or battery).
- The voltage of a cell（電池） is the electrical energy supplied by the cell when 1 C of charge has passed through the cell, with the current flowing from the negative terminal to the positive terminal.

$$\text{Voltage} = \frac{\text{electrical energy}}{\text{charge}} \quad \text{or} \quad V = \frac{E}{Q}$$

- Unit of voltage: J $C^{-1}$ or **volt** (V, 伏特 )
- Cells in series: the effective voltage is the sum of the voltages of individual cells.

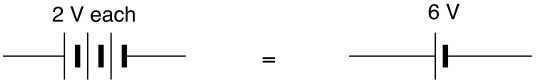



Figure 9.11

**Reminder**

A battery is a source of electrical energy but NOT of electric charges.

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.

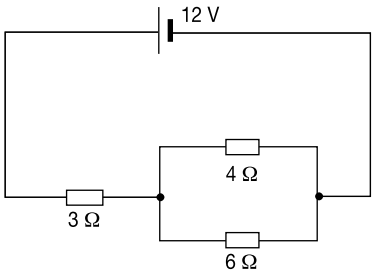



Figure 9.46

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.

## Section B

7.

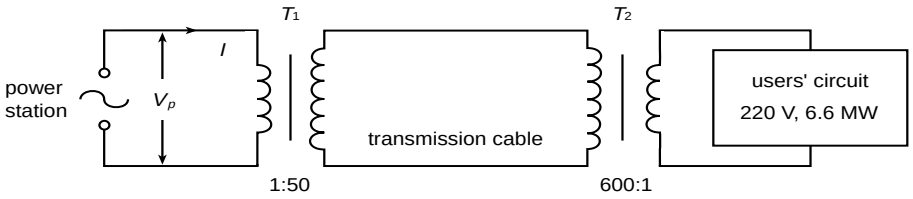



Figure 10.69

The above diagram shows a transmission network, in which the transmission cables between transformers $T_1$ and $T_2$ have a total resistance of 15 Ω. Extension Living Physics

(a) Find the current in the users' circuit. (2 marks)

(b) If the efficiency of $T_2$ is 95%, what is the current in the transmission cable? (3 marks)

(c) Find the power loss in the transmission cable. (2 marks)

(d) The efficiency of $T_1$ is 97%. Find the current $I$. (2 marks)

(e) Calculate the overall efficiency of electricity transmission by this network. (3 marks)

(f) Which forms of energy is the lost electrical energy being converted into? (2 marks)

8. Read the following passage about induction cooking and answer the questions that follow: Extension Living Physics

### Induction cooking

*An induction cooktop（電磁灶）supplies energy to a metallic cooking pan through a high-frequency magnetic field. The magnetic energy is transformed into heat within the metallic pan, which then heats and cooks the food in the pan. The ceramic cooktop itself does not give off heat and stays cool, except where the hot pan conducts heat back to the cooktop surface.*

*Some of the key advantages of induction cooking are:*

*(i) It is fast and efficient, because energy is directly transferred to the metal pan.*

*(ii) It is safe, because there is no open flame or red-hot coil to ignite flammable materials. This helps prevent fire.*

*(iii) It is cool, with induction, almost no wasted heat is produced since all the heat is generated within the pan itself.*

*(iv) It heats evenly, because the magnetic material within the cookware heats uniformly, and there are no hot spots.*

(a) Describe how electrical energy is converted into heat in an induction cooktop. (2 marks)

(b) Why it is more efficient to use induction heating than to cook with an open flame? Hint 7 (2 marks)

(c) Suggest one precaution when using an induction cooktop. (1 mark)

(d) Is induction cooking environmentally friendly? Explain briefly. (4 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 | long (years) | The activity is almost constant over a period of time. The source does not need to be replaced very often. |
| Radiotherapy (source placed outside patient's body) | long (years) | The activity is almost constant over a period of time. The source does not need to be replaced very often. |
| Radiotherapy (source delivered into patient's body) | short (hours or days) | To minimize the side effect on patients' body or the environment. |
| 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 $\alpha$ source is installed 4 cm from a radiation detector. Explain briefly how the detector works.

Figure 11.12

*Suggested Answer*

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

(b) $\alpha$ 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.

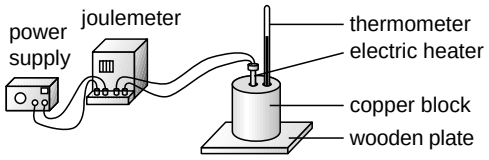
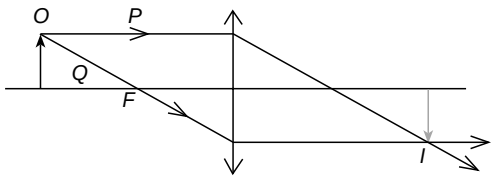
**Reminder**

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

# Index

# 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)<br>Ans:<br>$W = mg = 65 \times 10 = 650$ N (1A)<br><br>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)<br>Ans:<br>Work against friction = change in K.E.<br>or $F \times s = \frac{1}{2}mv^2$ (1M)<br>$800\ s = \frac{1}{2} \times 1200 \times 20^2$ (1M)<br>$s = 300$ m (1A) | • The exact numerical answer is expected.<br>• 1 mark question: a correct answer scores the mark<br>• 2 marks question: 1 mark for the correct formula used and 1 mark for the answer*<br>• 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*<br>* 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.<br>Ans:<br>  <br> | • The diagram should be labelled properly. Wrong spelling will score no mark.<br>• 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.<br>Ans:<br>  <br> | • Add lines, shapes or apparatus to the given diagram. |