# Grade 10 ADV Physics

مؤسسة الإمارات للتعليم المدرسي
EMIRATES SCHOOLS ESTABLISHMENT

# EOT 3 Sample Questions

2023/2024 Exam coverage

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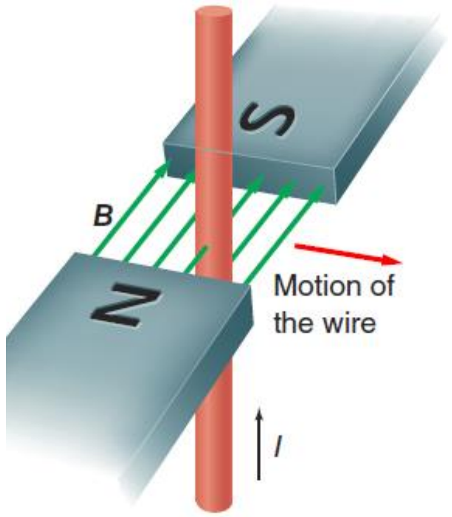
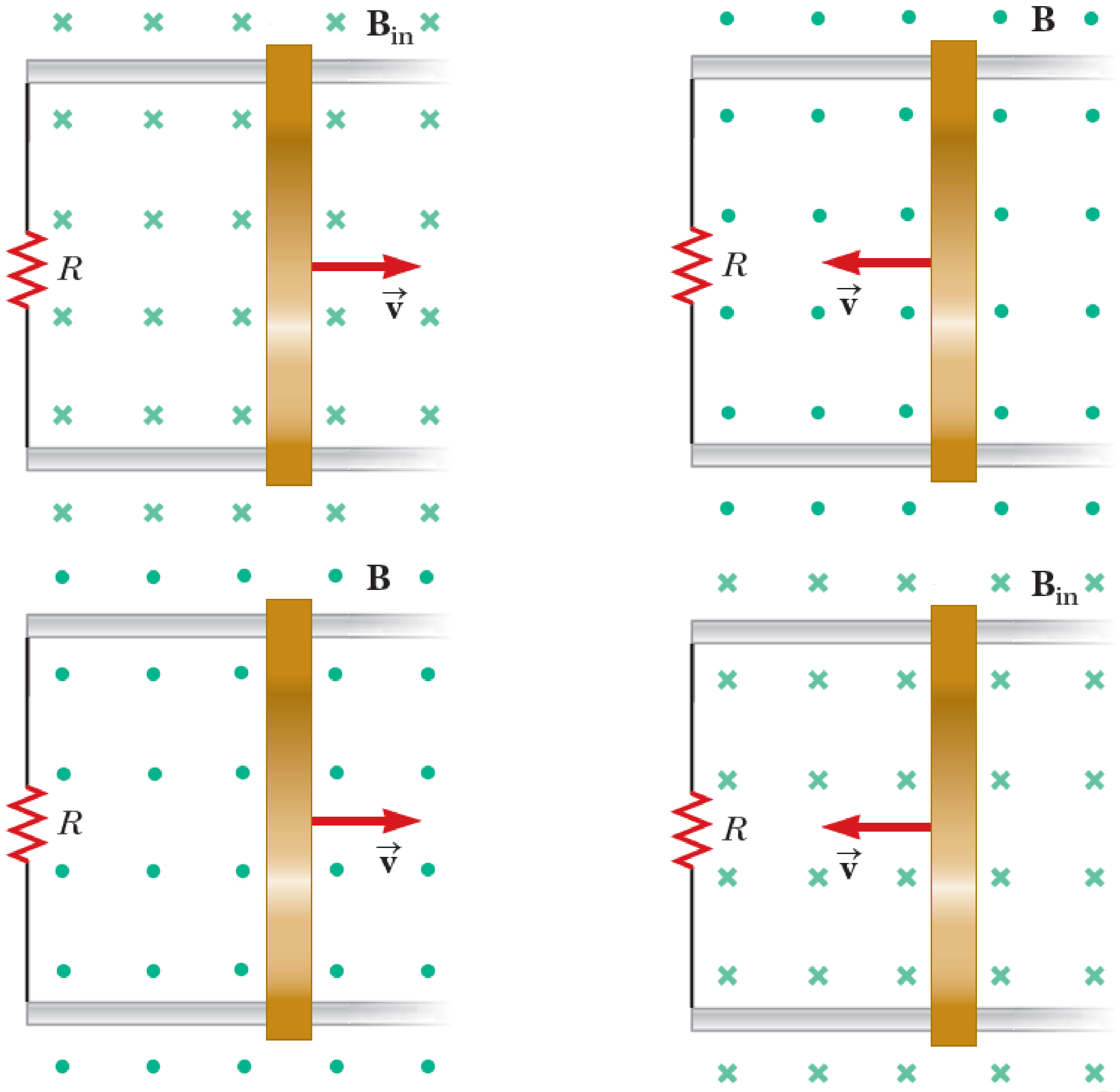
| | | | |
|---|---|---|---|
| 1 | 1. Explain how the relative motion between a conductor such as a wire and a magnetic field causes an induced emf.<br>2. Apply the right-hand rule to determine the direction of the induced emf and thus the direction of induced current in a wire moved in a magnetic field. | Student Book | 153-154 |
| | | Figure 2 | 153 |




indicate the direction of EMF and induced current



| | | | |
|---|---|---|---|
| 2 | Define electromotive force emf and specify its unit as volts (V). | Student Book | 153 |

Induced Electromotive Force (EMF): source of potential difference that moves charges, it is produced by a changing of magnetic field. e.g., generator.

1. Which dimensional analysis is correct for the calculation of *EMF*?

**A.** (N·A·m)(J)

**B.** (N/A·m)(m)(m/s)

**C.** J·C

**D.** (N·m·A/s)(1/m)(m/s)

4. Use unit substitution to show that the units of *BLv* are volts.

$V = J/C$

$C = As$

$J = Nm$

$$EMF = BLv \sin\theta$$

$$EMF = \left(\frac{N}{A.m}\right)(m)\left(\frac{m}{s}\right)\sin\theta = \frac{N.m}{A.s} = \frac{J}{C} = V(volt)$$

| 3 | Identify devices and machines that operate primarily on the principle of electromagnetic induction. | Student Book | 155-159 |
| --- | --- | --- | --- |
| | | Q.9-Q.12 | 159 |

**9. Electric Generator** Explain how an electric generator works.

An EMF is induced in the armature of a generator as it is turned—by a mechanical force—in a magnetic field. When the generator is in a circuit, the EMF induces a current. As the armature rotates through 180°, the induced EMF—and current—reverse direction.

**10. Generator** Could you make a generator by mounting permanent magnets on a rotating shaft and keeping the coil stationary? Explain.

Yes; only relative motion between the coil and magnetic field is important. Note, this generator would not have much power as the relative velocities of the magnets and coil will be very small.

**11. Bike Generator** A small generator on your bike lights the bike's headlight. What is the source of the energy for the bulb when you ride along a flat road?

The rider provides the mechanical energy that turns the generator's armature.

**12. Microphone** Consider the microphone shown in **Figure 3.** What happens when the diaphragm is pushed in?

A current is induced in the coil.

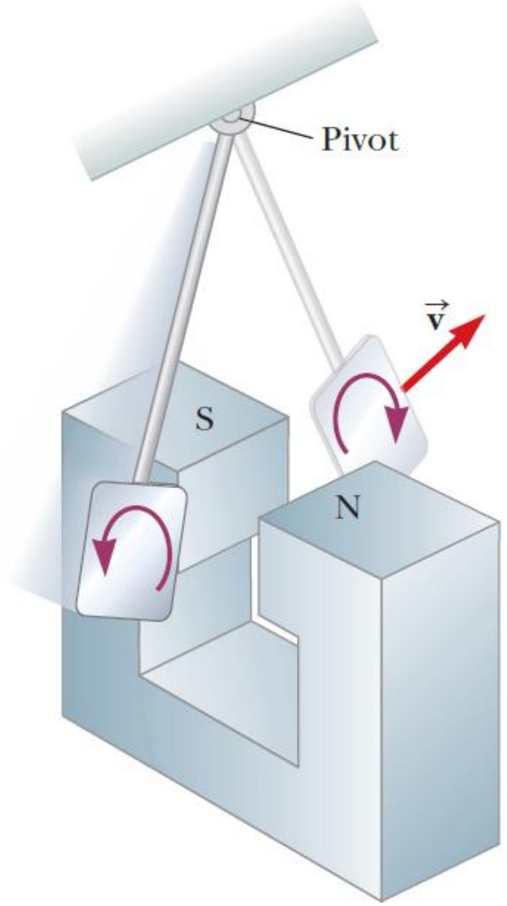
| | | | |
|---|---|---|---|
| 4 | Identify the phenomena associated with electromagnetic induction, which fulfills Lenz's law and confirms that there is no ideal physical quantity. | Student Book | 162 (Eddy currents) |

# Eddy Current:

current generated in any piece of metal (or sheet) moving through a magnetic field.

Eddy current is an induced current produces induced magnetic field that opposes the motion of metal in either direction.

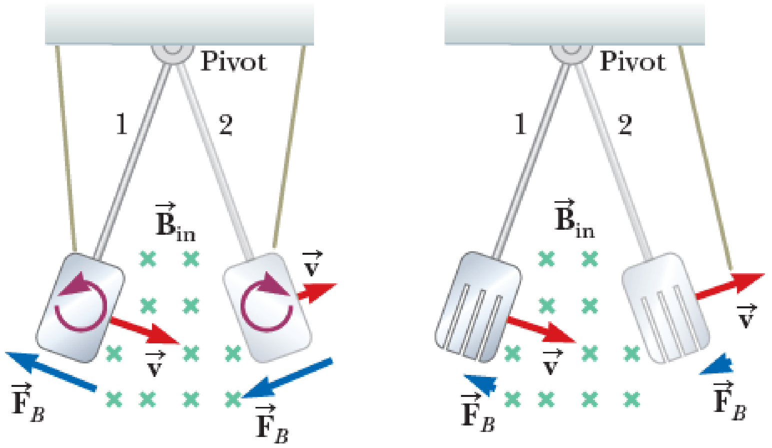
To reduce eddy currents circulation the metal constructed as thin layers.




Eddy currents are used to slow movement of metal parts.

e.g., the braking system of some trains and roller coasters.

e.g., stop swinging of laboratory balance.



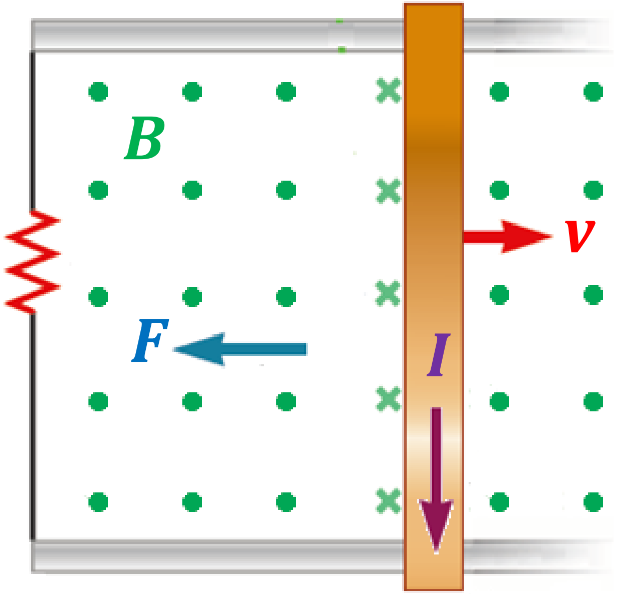
**Lenz's Law:**
magnetic field produced by induced current opposes the change of original field that produces induced current.

Lenz's law depends on the conservation of energy principle.

Faraday's law calculate the magnitude of induced EMF, then induced current.
Lenz's law explains the direction of induced current.

$EMF = BLv \rightarrow I$
motion produces current
Faraday's experiment

$F = ILB \rightarrow B$
current produces field
Oersted's experiment




$\Delta B \rightarrow EMF \rightarrow I_i \rightarrow B_i \rightarrow F_B$

induced quantities

$B_{induced}$ opposite to $\Delta B_{original}$
$F_B$ opposite to motion

| | | | |
|---|---|---|---|
| 6 | 1.Relate the effective current and effective potential difference to their maximum values in an AC circuit.<br>2.Calculate the maximum and effective values of current, voltage, and power for an AC generator. | Student Book | 158-159 |
| | | Q.5-Q.8, Q14-Q.15 | 159 |

## Practice problems (page 159)

**5.** A generator develops a maximum potential difference of 170 V.

a. What is the effective potential difference?

$$V_{\text{eff}} = 0.707V_{\text{max}} = 0.707(170) = 120\ \text{V}$$

b. A 60 W lamp is placed across the generator with an $I_{max}$ of 0.70. What is the effective current through the lamp?

$$I_{\text{eff}} = 0.707I_{\text{max}} = 0.707(0.7) = 0.5\ \text{A}$$

c. What is the resistance of the lamp when it is working?

$$R = \frac{P}{I_{eff}^2} = \frac{60}{0.5^2} = 240\ \Omega$$

**6.** The RMS potential difference of an AC household outlet is 117 V.

What is the maximum potential difference across a lamp connected to the outlet?

$$V_{\text{max}} = \frac{V_{\text{RMS}}}{0.707} = \frac{117}{0.707} = 165\ \text{V}$$

If the RMS current through the lamp is 5.5 A, what is the lamp's maximum current?

$$I_{\text{max}} = \frac{I_{\text{RMS}}}{0.707} = \frac{5.5}{0.707} = 7.8\ A$$

| | | | |
|---|---|---|---|
| 6 | 1.Relate the effective current and effective potential difference to their maximum values in an AC circuit.<br>2.Calculate the maximum and effective values of current, voltage, and power for an AC generator. | Student Book | 158-159 |
| | | Q.5-Q.8, Q14-Q.15 | 159 |

## Practice problems (page 159)

**7.** If the average power used over time by an electric light is 75 W, what is the peak power?

$$P_{AC} = \frac{1}{2} P_{peak}$$

$$P_{peak} = 2P_{AC}$$

$$P_{peak} = 2(75) = 150\ W$$

**8. CHALLENGE** An AC generator delivers a peak potential difference of 425 V.

a. What is the $V_{eff}$ in a circuit connected to the generator?

$$V_{eff} = 0.707 V_{max} = 0.707(425) = 300\ \mathrm{V}$$

b. The resistance is $5.0\times10^2\ \Omega$. What is the effective current?

$$I_{eff} = \frac{V_{eff}}{R} = \frac{300}{5 \times 10^2} = 0.6\ A$$

| | | | |
|---|---|---|---|
| 6 | 1.Relate the effective current and effective potential difference to their maximum values in an AC circuit.<br>2.Calculate the maximum and effective values of current, voltage, and power for an AC generator. | Student Book | 158-159 |
| | | Q.5-Q.8, Q14-Q.15 | 159 |

**14. Output Potential Difference** Explain why the output potential difference of an electric generator increases when the magnetic field is made stronger. What is another way to increase the output potential difference?

The magnitude of the induced EMF is directly related to the strength of the magnetic field. A greater potential difference is induced in the conductor(s) if the field strength is increased. Because EMF = BLv (sin θ), you can also increase output potential difference by increasing the length of the wire or the velocity of the wire.

**15. Critical Thinking** A student asks, "Why does AC dissipate power? The energy going into a lamp when the current is positive is removed when the current is negative. The net current is zero." Explain why this reasoning is wrong.

Power is the rate at which energy is transferred. Power is the product of I and V. When I is positive, so is V, and therefore, P is positive. When I is negative, so is V; thus, P is positive. Energy is always transferred through the lamp.

| | | | |
|---|---|---|---|
| 7 | Apply the equation EMF= BLv(sin θ) to determine the magnitude of induced emf for a wire moving through a magnetic field. | student Book | 153-155 |
| | | Q.1-Q.4 | 155 |

## Practice problems (page 155)

**1.** You move a straight wire that is 0.5 m long at a speed of 20 m/s vertically through a 0.4 T magnetic field pointed in the horizontal direction.

a. What EMF is induced in the wire?

$$EMF = BLv\sin\theta$$

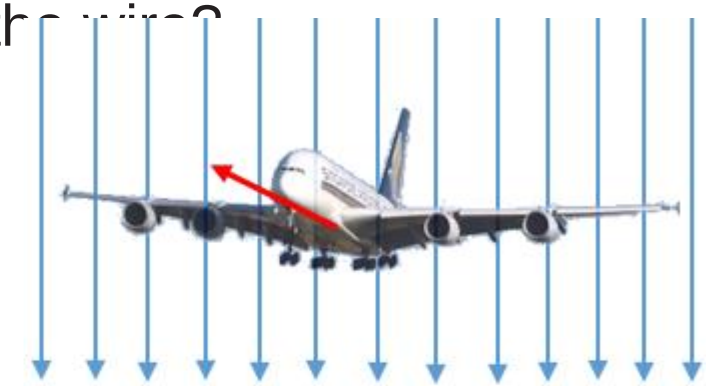
$$= 20(0.5)(0.4)\sin 90 = 4\ V$$

b. The wire is part of a circuit with a total resistance of 6.0 Ω. What is the current?

$$EMF = IR$$

$$I = \frac{EMF}{R} = \frac{4}{6} = 0.7\ \text{A}$$

**2.** A straight wire that is 25 m long is mounted on an airplane flying at 125 m/s. The wire moves in a perpendicular direction through Earth's magnetic field $(B = 5.0\times10^{-5}\ T)$. What EMF is induced in the wire?



$$EMF = BLv\sin\theta$$

$$= 125(25)(5\times10^{-5})\sin 90$$

$$= 0.16\ \text{V}$$

| | | | |
|---|---|---|---|
| 7 | Apply the equation EMF= BLv(sin θ) to determine the magnitude of induced emf for a wire moving through a magnetic field. | student Book | 153-155 |
| | | Q.1-Q.4 | 155 |

# Practice problems (page 155)

**3.** A straight wire segment in a circuit is 30.0 m long and moves at 2.0 m/s perpendicular to a magnetic field.

a. A 6.0 V EMF is induced. What is the magnetic field?

$$EMF = BLv\sin\theta$$

$$B = \frac{EMF}{Lv\sin\theta} = \frac{6}{(30)(2)\sin 90} = 0.1\ T$$

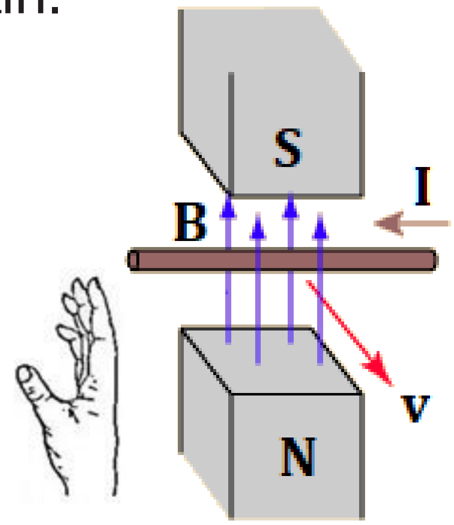
b. The total resistance of the circuit is 5.0 Ω. What is the current?

$$EMF = IR$$

$$I = \frac{EMF}{R} = \frac{6}{5} = 1.2\ \text{A}$$

**4. CHALLENGE** A horseshoe magnet is mounted so that the magnetic field lines are vertical. You pass a straight wire between the poles and pull it toward you. The current through the wire is from right to left. Which is the magnet's north pole? Explain.

Using a right-hand rule, the north pole is at the bottom.



| 8 | Calculate the speed of electromagnetic waves in different mediums of different dielectric constants. | Student Book | 180-181 |
|---|---|---|---|
| | | Q.42-Q.45 | 181 |

# Practice problems (page 181)

**42.** What is the speed of an electromagnetic wave traveling through air?
Use c = 299,792,458 m/s in your calculation.

$$v = \frac{c}{\sqrt{k}}$$

$$v = \frac{299792458}{\sqrt{1.00054}} = 299711546.8\, m/s$$

**43.** Water has a dielectric constant of 1.77. What is the speed of light in water?

$$v = \frac{c}{\sqrt{k}} = \frac{3 \times 10^8}{\sqrt{1.77}} = 2.25 \times 10^8\, m/s$$

| 8 | Calculate the speed of electromagnetic waves in different mediums of different dielectric constants. | Student Book | 180-181 |
|---|---|---|---|
| | | Q.42-Q.45 | 181 |

## Practice problems (page 181)

44. The speed of light traveling through a material is $2.43 \times 10^8 m/s$. What is the dielectric constant of the material?

$$v = \frac{c}{\sqrt{k}}$$

$$k = \left(\frac{c}{v}\right)^2$$

$$k = \left(\frac{3 \times 10^8}{2.43 \times 10^8}\right)^2 = 1.524$$

**45. CHALLENGE** A radio signal is transmitted from Earth's surface to the Moon's surface, 376,290 km away. What is the shortest time a reply can be expected?

The signal must reach the moon then come back to earth

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

$$t = \frac{d}{v} \quad = \frac{2(376290 \times 10^3)}{3 \times 10^8} = 2.5\ s$$

| 9 | Apply the wave equation to calculate the wavelength, frequency, or speed of electromagnetic waves. | Student Book | 176-177 |
|---|---|---|---|
| | | Q.38-Q.40 | 177 |

# Practice problems (page 177)

**38.** What is the wavelength of green light that has a frequency of $5.7 \times 10^{14}$ Hz and travel in vacuum?

$$c = \lambda f$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^{8}}{5.7 \times 10^{14}} = 5.3 \times 10^{-7} \text{ m}$$

**39.** An electromagnetic wave has a frequency of $8.2 \times 10^{14}$ Hz. What is the wavelength of the wave?

$$c = \lambda f$$

$$\lambda = \frac{c}{\text{f}} = \frac{3 \times 10^{8}}{8.2 \times 10^{14}} = 3.7 \times 10^{-7} \text{ Hz}$$

| | | | |
|---|---|---|---|
| 9 | Apply the wave equation to calculate the wavelength, frequency, or speed of electromagnetic waves. | Student Book | 176-177 |
| | | Q.38-Q.40 | 177 |

## Practice problems (page 177)

**40.** What is the frequency of an EM wave of a wavelength of $2.2 \times 10^{-2}$ m and travel in vacuum?

$$c = \lambda f$$

$$f = \frac{c}{\lambda} = \frac{3 \times 10^{8}}{2.2 \times 10^{-2}} = 1.4 \times 10^{10}\ \text{Hz}$$

| | | | |
|---|---|---|---|
| 10 | Determine the optimal length or orientation of an antenna for the best reception of a given wave. | Student Book | 183-184 |
| | | Q.49, Q.51 | 185 |

**49.Radio Signals** Radio antennas normally have metal rod elements that are oriented horizontally. From this information, what can you deduce about the directions of the electric fields in radio signals?

They must also be horizontal.

**50. Digital Signals** What are the advantages of storing and transmitting sound, pictures, and data as digital signals?

Digital signals can be stored reliably in computer memory and sent over long distances.

They can send more information in the same amount of time as AM or FM and are less affected by noise.

**51. Antenna Design** Would an FM antenna designed to be most sensitive to stations near 88 MHz be shorter or longer than one designed to receive stations near 108 MHz? Explain your reasoning.

Longer; lower-frequency waves would have longer wavelengths, so they use a longer antenna.

**Wire antennas** When an antenna is one-half the length of the wave it is designed to detect, the potential difference across its terminals is largest and the antenna is most efficient. Therefore, an antenna designed to receive radio waves is longer than one designed to receive microwaves.

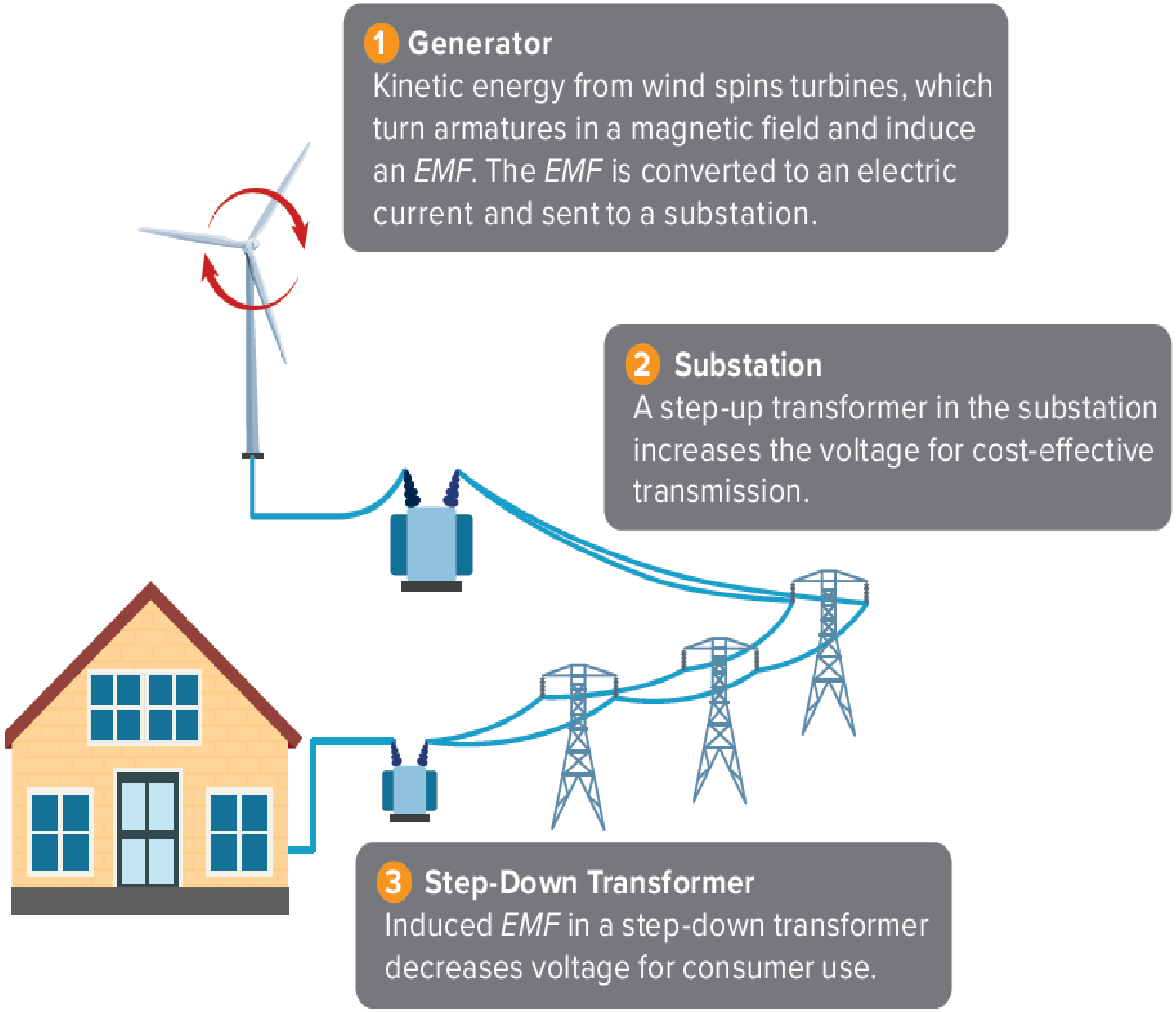
| | | | |
|---|---|---|---|
| 11 | Explain how transformers are used in the National Grid System to transmit power through long distances with minimal power losses. | Student Book | 167 |
| | | Figure 16 | 167 |

## Everyday uses of transformers

Long-distance transmission of electrical energy is economical only if very high potential differences are used.

High potential differences reduce the current required in the transmission lines, keeping the wasteful energy transformations low.

As shown in Figure 16, step-up transformers are used at power sources, where they can develop potential differences up to 480,000 V. When the energy reaches homes, step-down transformers reduce the potential difference to 120 V. Game systems, printers, laptop computers, and rechargeable toys have transformers inside their casings or in blocks attached to their cords. These small transformers further reduce potential differences from wall outlets to the 3 V–26 V range.



| 12 | Derive the relation of the wavelength from double-slit investigation (λ=xd/L) where 'x' is the distance on the screen from the central bright fringe to the first bright band, 'd' is the distance between the slits, and 'L' is the distance from the slits to the screen. | Student Book | 195-196 |
|---|---|---|---|
| | | Q.1-Q.5 | 196 |

## Practice problems (page 196)

**1.** Violet light falls on two slits separated by $1.90 \times 10^{-5}$ m. A first-order bright band appears 13.2 mm from the central bright band on a screen 0.600 m from the slits. What is λ?

$$\lambda = \frac{xd}{L}$$

$$\lambda = \frac{(13.2 \times 10^{-3})(1.9 \times 10^{-5})}{(0.6)}$$

$$\lambda = 4.18 \times 10^{-7} m$$

**2.** Yellow-orange light from a sodium lamp of wavelength 596 nm is aimed at two slits that are separated by $1.90 \times 10^{-5}$ m. What is the distance from the central band to the first-order yellow band if the screen is 0.600 m from the slits?

$$\lambda = \frac{xd}{L}$$

$$596 \times 10^{-9} = \frac{x(1.9 \times 10^{-5})}{(0.6)}$$

$$x = \frac{(596 \times 10^{-9})(0.6)}{(1.9 \times 10^{-5})} = 0.0188\, m$$

| 12 | Derive the relation of the wavelength from double-slit investigation (λ=xd/L) where 'x' is the distance on the screen from the central bright fringe to the first bright band, 'd' is the distance between the slits, and 'L' is the distance from the slits to the screen. | Student Book | 195-196 |
|---|---|---|---|
| | | Q.1-Q.5 | 196 |

## Practice problems (page 196)

**3.** In a double-slit investigation, physics students use a laser with λ = 632.8 nm. A student places the screen 1.000 m from the slits and finds the first-order bright band 65.5 mm from the central line. What is the slit separation?

$$\lambda = \frac{xd}{L}$$

$$632.8 \times 10^{-9} = \frac{(65.5 \times 10^{-3})d}{(1)}$$

$$d = \frac{(632.8 \times 10^{-9})(1)}{(65.5 \times 10^{-3})} = 9.66 \times 10^{-6} m$$

**4. CHALLENGE** Yellow-orange light with a wavelength of 596 nm passes through two slits that are separated by $2.25 \times 10^{-5}$ m and makes an interference pattern on a screen. If the distance from the central line to the first-order yellow band is $2.00 \times 10^{-2}$ m, how far is the screen from the slits?

$$\lambda = \frac{xd}{L}$$

$$596 \times 10^{-9} = \frac{(2 \times 10^{-2})(2.25 \times 10^{-5})}{L}$$

$$L = \frac{(2 \times 10^{-2})(2.25 \times 10^{-5})}{(596 \times 10^{-9})} = 0.755 m$$

# Interference of Coherent Light:

## Young, double slit experiment:

The overlapping light from the two slits fell on an observing screen.

The overlap created a pattern of bright and dark bands called **interference fringes.**

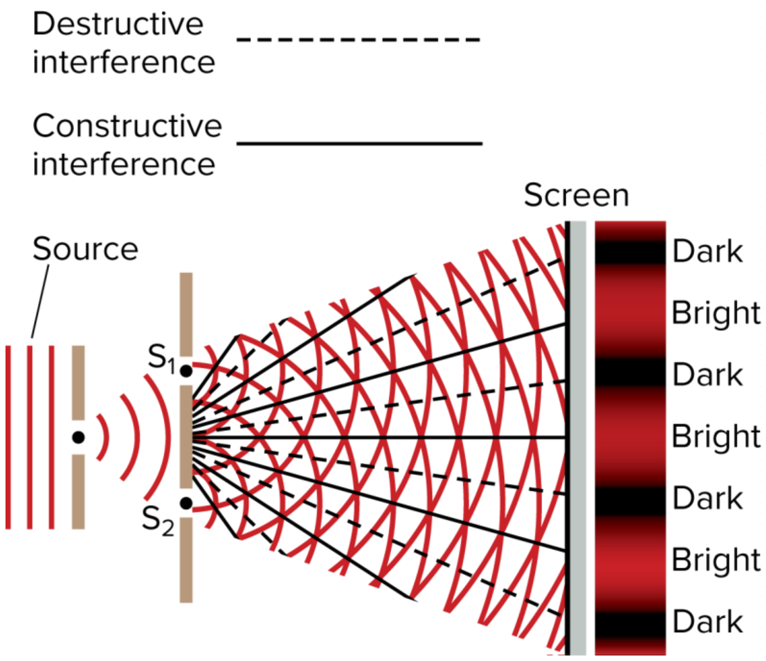
- Constructive interference produces a bright central band of the given color on the screen, as well as other bright bands of near-equal spacing and near-equal width on either side, as shown in **Figure 3.**

- The intensity of the bright bands decreases the farther the band is from the central band, as you can see.

- Between the bright bands are dark areas where destructive interference occurs.

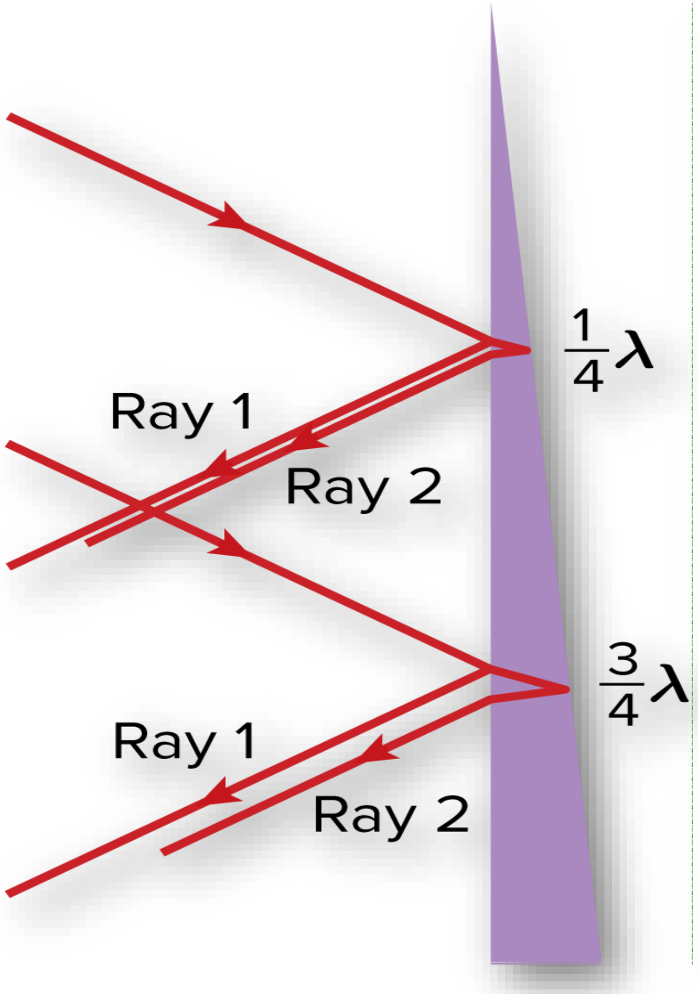
- The positions of the constructive and destructive interference bands depend on the light's wavelength.

Double-Slit Interference Top View



# Thin film interference:

the phenomenon of a spectrum of colors resulting from constructive and destructive interference of light waves due to reflection from separate surfaces in a thin film.



| 15 | Define the phenomenon of thin-film interference. | Student Book | 197-200 |
|---|---|---|---|

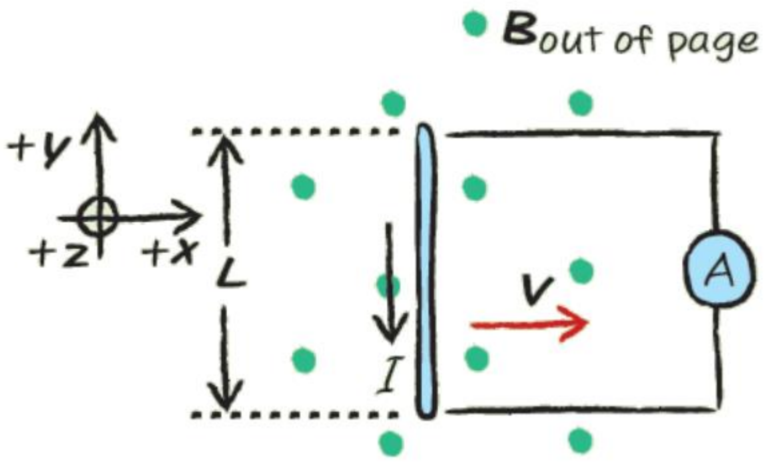
## Thin film interference:

the phenomenon of a spectrum of colors resulting from constructive and destructive interference of light waves due to reflection from separate surfaces in a thin film.

| Q1 | 1. Explain how the relative motion between a conductor such as a wire and a magnetic field causes an induced emf.<br>2. Apply the equation EMF=BLv(sin θ) to determine the magnitude of induced emf for a wire moving through a magnetic field.<br>3. Apply the equation I=EMF/R to calculate the magnitude of induced current in a wire that is part of a closed circuit. | Student Book | 152-158 |
|---|---|---|---|
| | | Example Problem 1, Q.1-Q.4 | 154-155 |

## Example problem (page 154)

**Induced EMF** A straight wire is part of a circuit that has a resistance of 0.50 Ω. The wire is 0.20 m long and moves at a constant speed of 7.0 m/s perpendicular to a magnetic field of strength 8.0 x $10^{-2}$ T.




(a) What EMF is induced in the wire?

$$EMF = BLv\sin\theta$$
$$= 7(0.2)(8\times10^{-2})\sin 90$$
$$= 0.11\text{ V}$$

(b) What is the current through the wire?

$$EMF = IR$$

$$I = \frac{EMF}{R} = \frac{0.11}{0.5} = 0.22\text{ A}$$

(c) If a different metal were used for the wire, increasing the circuit's resistance to 0.78 Ω, what would the new current be?

$$I = \frac{EMF}{R'} = \frac{0.11}{0.78} = 0.14\text{ A}$$

| | | | |
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## Practice problems (page 155)

**1.** You move a straight wire that is 0.5 m long at a speed of 20 m/s vertically through a 0.4 T magnetic field pointed in the horizontal direction.

a. What EMF is induced in the wire?

$$EMF = BLv\sin\theta$$

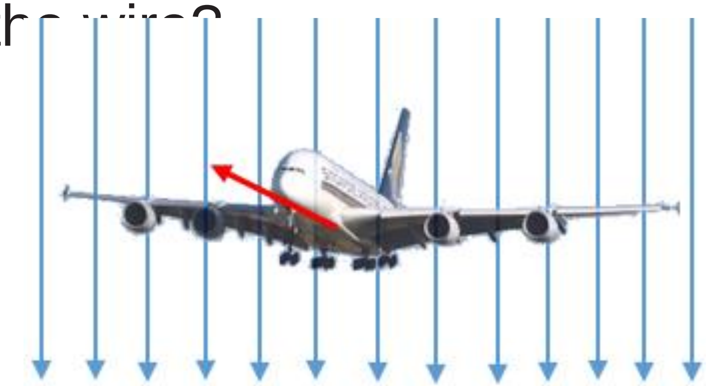
$$= 20(0.5)(0.4)\sin 90 = 4\ V$$

b. The wire is part of a circuit with a total resistance of 6.0 Ω. What is the current?

$$EMF = IR$$

$$I = \frac{EMF}{R} = \frac{4}{6} = 0.7\ \text{A}$$

**2.** A straight wire that is 25 m long is mounted on an airplane flying at 125 m/s. The wire moves in a perpendicular direction through Earth's magnetic field ($B = 5.0\times10^{-5}$ T). What EMF is induced in the wire?



$$EMF = BLv\sin\theta$$

$$= 125(25)(5\times10^{-5})\sin 90$$

$$= 0.16\ \text{V}$$

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| Q1 | 1. Explain how the relative motion between a conductor such as a wire and a magnetic field causes an induced emf.<br>2. Apply the equation EMF=BLv(sin θ) to determine the magnitude of induced emf for a wire moving through a magnetic field.<br>3. Apply the equation I=EMF/R to calculate the magnitude of induced current in a wire that is part of a closed circuit. | Student Book | 152-158 |
| | | Example Problem 1, Q.1-Q.4 | 154-155 |

# Practice problems (page 155)

**3.** A straight wire segment in a circuit is 30.0 m long and moves at 2.0 m/s perpendicular to a magnetic field.

a. A 6.0 V EMF is induced. What is the magnetic field?

$$EMF = BLv\sin\theta$$

$$B = \frac{EMF}{Lv\sin\theta} = \frac{6}{(30)(2)\sin 90} = 0.1\ T$$

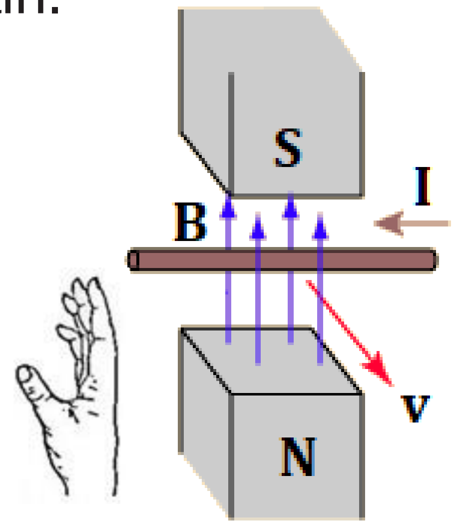
b. The total resistance of the circuit is 5.0 Ω. What is the current?

$$EMF = IR$$

$$I = \frac{EMF}{R} = \frac{6}{5} = 1.2\ \text{A}$$

**4. CHALLENGE** A horseshoe magnet is mounted so that the magnetic field lines are vertical. You pass a straight wire between the poles and pull it toward you. The current through the wire is from right to left. Which is the magnet's north pole? Explain.

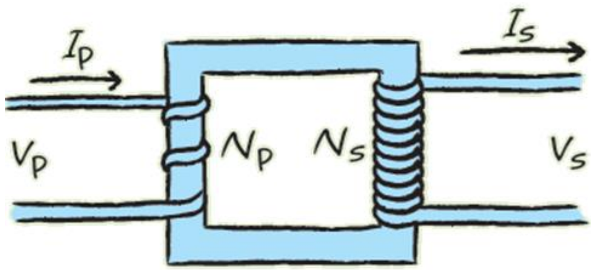
Using a right-hand rule, the north pole is at the bottom.



| | | | |
|---|---|---|---|
| Q2 | 1. Relate the turn's ratio of a transformer to its corresponding voltage ratio and apply the corresponding equation in problem solving.<br>2. Apply the ideal transformer equation to solve numerical problems.<br>3. Differentiate between step-up and step-down transformers. | Student Book | 164-166 |
| | | Example Problem 2, Q.16-Q.17; Table | 166, 165 |

## Example problem (page 166)

**STEP-UP TRANSFORMERS:** A step-up transformer has a primary coil consisting of 200 turns and a secondary coil consisting of 3000 turns. The primary coil is supplied with an effective AC potential difference of 90.0 V.




**a.** What is the potential difference in the secondary circuit?

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$V_s = \frac{N_s}{N_p} V_p$$

$$V_s = \frac{(3000)(90)}{200} = 1350\ V$$

**b.** The current in the secondary circuit is 2.0 A. What is the current in the primary circuit?

$$P_p = P_s$$

$$I_p V_p = I_s V_s$$

$$I_p = \frac{I_s V_s}{V_p} = \frac{(1350)(2)}{(90)} = 30\ A$$

| | | | |
|---|---|---|---|
| Q2 | 1. Relate the turn's ratio of a transformer to its corresponding voltage ratio and apply the corresponding equation in problem solving.<br>2. Apply the ideal transformer equation to solve numerical problems.<br>3. Differentiate between step-up and step-down transformers. | Student Book | 164-166 |
| | | Example Problem 2, Q.16-Q.17; Table | 166, 165 |

# Practice problems (page 166)

**16.** A step-down transformer has 7500 turns on its primary coil and 125 turns on its secondary coil. The potential difference across the primary circuit is 7.2 kV.

a. What is the potential difference across the secondary circuit?

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$V_s = \frac{N_s}{N_p} V_p$$

$$V_s = \frac{(125)}{(7500)} (7.2 \times 10^3)$$

$$V_s = 120\ V$$

b. If the current in the secondary circuit is 36 A, what is the current in the primary circuit?

$$\frac{N_p}{N_s} = \frac{I_s}{I_p}$$

$$I_p = \frac{I_s N_s}{N_p}$$

$$I_p = \frac{(36)(120)}{(7.2 \times 10^3)} = 0.6\ A$$

c. Calculate input power

$$P_{\text{in}} = I_p V_p$$

$$P_{\text{in}} = (0.6)(7200)$$

$$P_{\text{in}} = 4320\ \text{W}$$

| Q2 | 1. Relate the turn's ratio of a transformer to its corresponding voltage ratio and apply the corresponding equation in problem solving.<br>2. Apply the ideal transformer equation to solve numerical problems.<br>3. Differentiate between step-up and step-down transformers. | Student Book | 164-166 |
|---|---|---|---|
| | | Example Problem 2, Q.16-Q.17; Table | 166, 165 |

## Practice problems (page 166)

**17. CHALLENGE** A step-up transformer has 300 turns on its primary coil and 90,000 turns on its secondary coil. The potential difference of the generator to which the primary circuit is attached is 60 V. The transformer is 95 percent efficient.

a. What is the potential difference across the secondary circuit?

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$V_s = \frac{N_s}{N_p} V_p$$

$$V_s = \frac{(90000)}{(300)}(60) = 18000V$$

b. The current in the secondary circuit is 0.5 A. What current is in the primary circuit?

$$\varepsilon = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100\%$$

$$\varepsilon = \frac{I_s V_s}{I_p V_p}$$

$$I_p = \frac{I_s V_s}{\varepsilon V_p}$$

$$I_p = \frac{(0.5)(18000)}{\left(\frac{95}{100}\right)(60)}$$

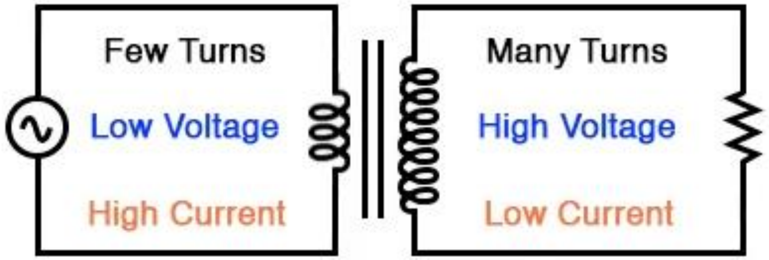
$$I_p = 158 \text{ A}$$

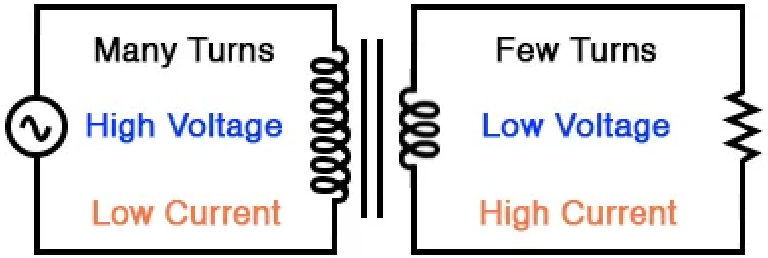
| | | | |
|---|---|---|---|
| Q2 | 1. Relate the turn's ratio of a transformer to its corresponding voltage ratio and apply the corresponding equation in problem solving.<br>2. Apply the ideal transformer equation to solve numerical problems.<br>3. Differentiate between step-up and step-down transformers. | Student Book | 164-166 |
| | | Example Problem 2, Q.16-Q.17; Table | 166, 165 |

## CONNECTING MATH to Physics

**Inequalities** Study the following expressions to help you understand the relationships among potential difference (*V*), current (*I*), and the number of coils in transformers (*N*) in primary and secondary circuits.

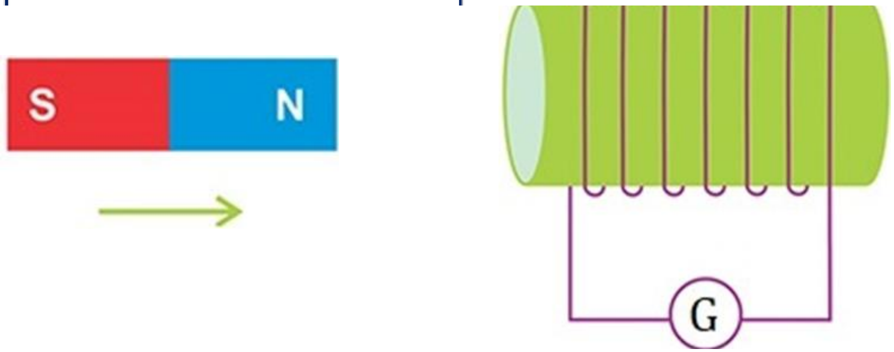
| Step-Up Transformer | Step-Down Transformer |
|---|---|
| $V_p < V_s$ | $V_p > V_s$ |
| $I_p > I_s$ | $I_p < I_s$ |
| $N_p < N_s$ | $N_p > N_s$ |



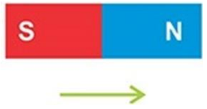
| | | | |
|---|---|---|---|
| Q3 | 1. Determine the type of pole induced on the face of a coil and the direction of induced current in a coil when a coil and a magnet are in relative motion.<br>2. Define coherent and incoherent light.<br>3. Explain how bright and dark interference fringes are created in a double-slit interference investigation with monochromatic light.<br>4. Recall the concepts of constructive and destructive interference and define interference fringes of light. | Student Book | 160-161; 193; 193-196 |
| | | Figure 10; Figure 5 | 161, 193; 194 |

2. Look at the figures and answer the following questions:



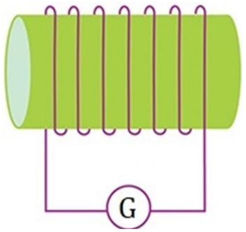

a) The direction of original magnetic field (from the magnet):

Right, field lines com out from north and enter the south.



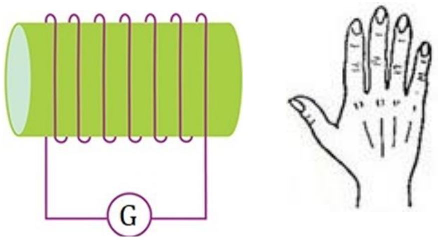

b) The induced magnetic pole appears on the left side of coil is:

North, the magnet is moving towards the coil. Original field increase, the coil will induce a field in the opposite direction to the original field.



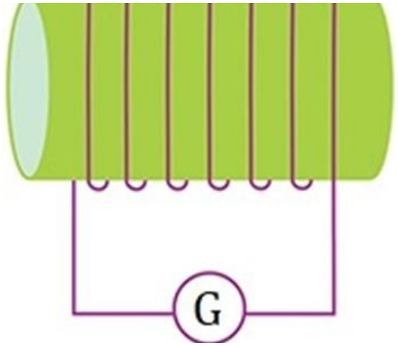

c) The direction of the induced current passes through galvanometer:

From left to Right, using the right hand rile. (thump with the direction of the induced field , fingers show the direction of the induced current)



| | | | |
|---|---|---|---|
| Q3 | 1. Determine the type of pole induced on the face of a coil and the direction of induced current in a coil when a coil and a magnet are in relative motion.<br>2. Define coherent and incoherent light.<br>3. Explain how bright and dark interference fringes are created in a double-slit interference investigation with monochromatic light.<br>4. Recall the concepts of constructive and destructive interference and define interference fringes of light. | Student Book | 160-161; 193; 193-196 |
| | | Figure 10; Figure 5 | 161, 193; 194 |

## 3. Look at the figures and answer the following questions:

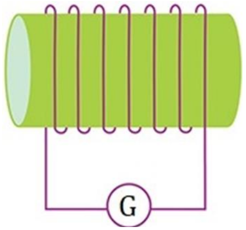




a) The direction of original magnetic field (from the magnet):

Right, field lines com out from north and enter the south.

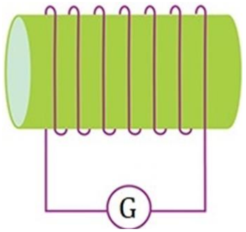

b) The induced magnetic pole appears on the left side of coil is:

South, the magnet is moving away from the coil. Original field decrease, the coil will induce a field in the same direction as the original field.

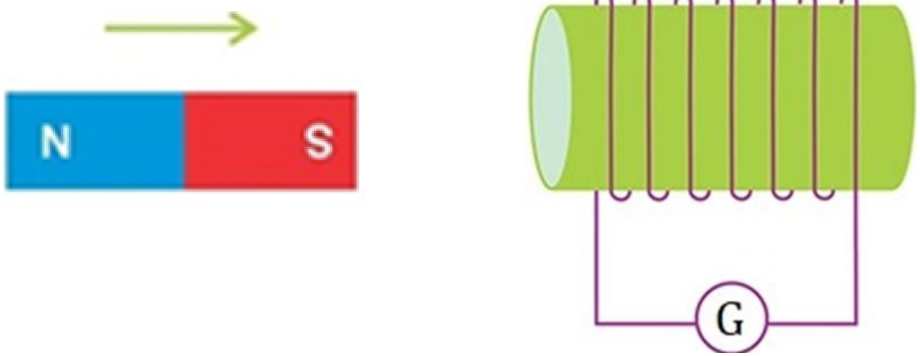



c) The direction of the induced current passes through galvanometer:

From right to left, using the right hand rile. (thump with the direction of the induced field , fingers show the direction of the induced current)




| | | | |
|---|---|---|---|
| Q3 | 1. Determine the type of pole induced on the face of a coil and the direction of induced current in a coil when a coil and a magnet are in relative motion.<br>2. Define coherent and incoherent light.<br>3. Explain how bright and dark interference fringes are created in a double-slit interference investigation with monochromatic light.<br>4. Recall the concepts of constructive and destructive interference and define interference fringes of light. | Student Book | 160-161; 193; 193-196 |
| | | Figure 10; Figure 5 | 161, 193; 194 |

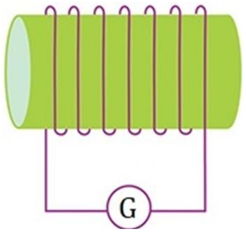



4. Look at the figures and answer the following questions:

a) The direction of original magnetic field (from the magnet):

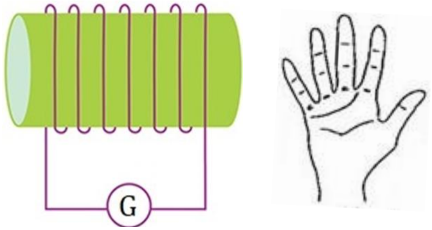

Left, field lines com out from north and enter the south.

b) The induced magnetic pole appears on the left side of coil is:




South, the magnet is moving towards the coil. Original field increase, the coil will induce a field opposite to the original field.

c) The direction of the induced current passes through galvanometer:




From right to left, using the right hand rile. (thump with the direction of the induced field , fingers show the direction of the induced current)

| | | | |
|---|---|---|---|
| Q3 | 1. Determine the type of pole induced on the face of a coil and the direction of induced current in a coil when a coil and a magnet are in relative motion.<br>2. Define coherent and incoherent light.<br>3. Explain how bright and dark interference fringes are created in a double-slit interference investigation with monochromatic light.<br>4. Recall the concepts of constructive and destructive interference and define interference fringes of light. | Student Book<br>Figure 10; Figure 5 | 160-161; 193; 193-196<br>161, 193; 194 |

**Incoherent light:** A light whose waves are not in phase, such as white light from a light bulb.

The effect of incoherence in waves can be seen in the example of heavy rain falling on still water. The surface of the water is choppy and does not have a regular pattern of waves, as shown in Figure 1. Because light waves have such a high frequency, incoherent light does not appear choppy to you. Instead, as light from an incoherent white light source illuminates an object, you see the combination of the incoherent light waves as an even, white light.

Incoherent Wave

**Coherent light:** Light made up of waves of the same wavelength that are in phase with each other.

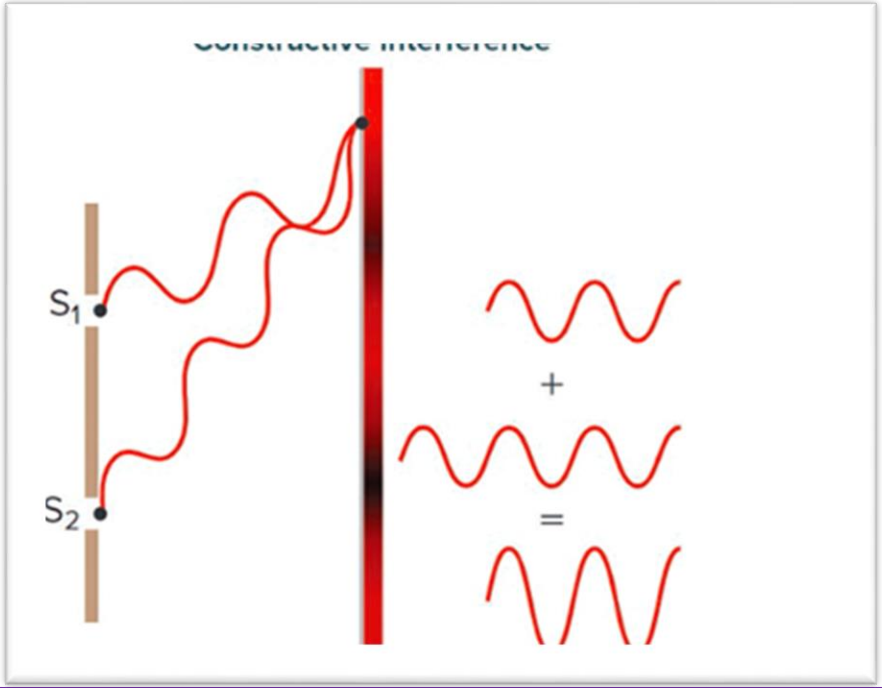
A regular wavefront, which is made of coherent light, can be created by a single point source, as shown in Figure 2. A regular wavefront also can be created by multiple point sources when all point sources are in phase. This type of coherent light is produced by a laser.

Coherent Wave

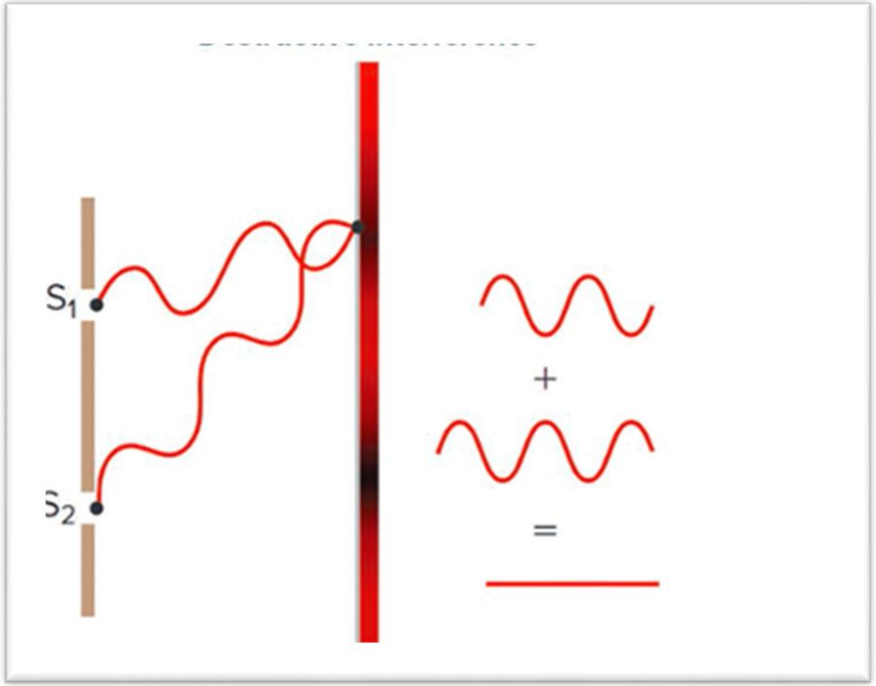
| | | | |
|---|---|---|---|
| Q3 | 1. Determine the type of pole induced on the face of a coil and the direction of induced current in a coil when a coil and a magnet are in relative motion.<br>2. Define coherent and incoherent light.<br>3. Explain how bright and dark interference fringes are created in a double-slit interference investigation with monochromatic light.<br>4. Recall the concepts of constructive and destructive interference and define interference fringes of light. | Student Book | 160-161; 193; 193-196 |
| | | Figure 10; Figure 5 | 161, 193; 194 |

The result of the superposition of tow or more waves.

**Constructive interference**, in which two waves (of the same wavelength) interact in such a way that they are aligned, leading to a new wave that is bigger than the original wave




**Destructive interference**, in which two waves (with the same amplitude) are shifted by exactly half a wavelength when they merge, they will cancel each other out.



| | | | |
|---|---|---|---|
| Q4 | 1. Apply the relation (λ=xd/L) to calculate the wavelength or to find an unknown distance in a double-slit investigation given the other values.<br>2. Show that the intensity of bright bands decreases as you go farther from the central band (double slit interference with monochromatic light).<br>3. Explain the formation of a colored spectra when white light is used in a double-slit investigation.<br>4. Solve problems on interference of light. | Student Book | 193-196 |
| | | Example Problem 1, Q.1-Q.4; Example Problem 2, Q.5-Q.9 | 196; 197-200; 199 |

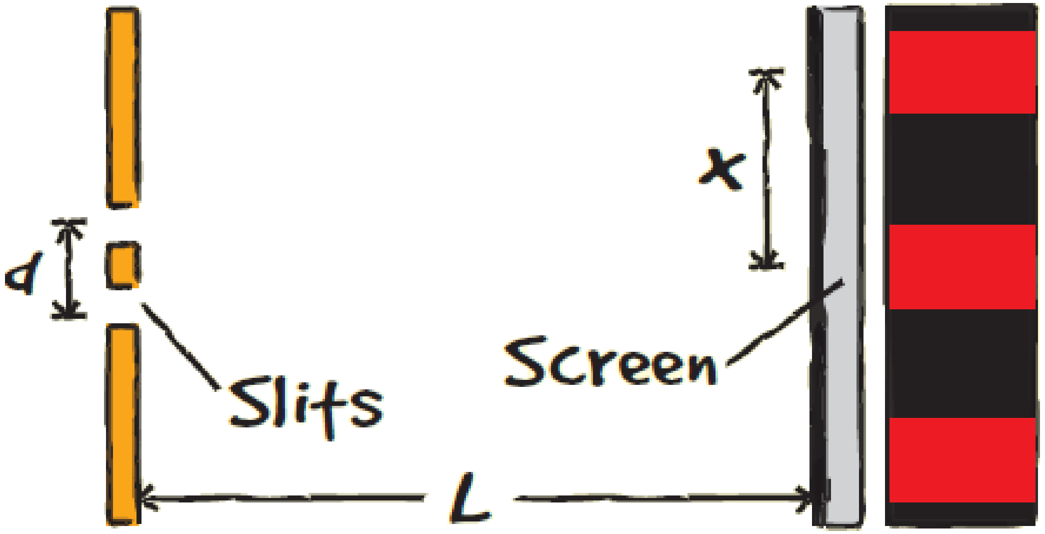
## Example problem (page 196)

**WAVELENGTH OF LIGHT** A double-slit investigation is performed to measure the wavelength of red light. The slits are 0.0190 mm apart. A screen is placed 0.600 m away, and the first-order bright band is 21.1 mm from the central bright band. What is the wavelength of the red light?

$$\lambda = \frac{xd}{L}$$

$$\lambda = \frac{(2.11 \times 10^{-2})(0.019 \times 10^{-3})}{(0.6)}$$

$$\lambda = 6.68 \times 10^{-7} m$$



| | | | |
|---|---|---|---|
| Q4 | 1. Apply the relation (λ=xd/L) to calculate the wavelength or to find an unknown distance in a double-slit investigation given the other values.<br>2. Show that the intensity of bright bands decreases as you go farther from the central band (double slit interference with monochromatic light).<br>3. Explain the formation of a colored spectra when white light is used in a double-slit investigation.<br>4. Solve problems on interference of light. | Student Book | 193-196 |
| | | Example Problem 1, Q.1-Q.4;<br>Example Problem 2, Q.5-Q.9 | 196; 197-200; 199 |

**1.** Violet light falls on two slits separated by $1.90 \times 10^{-5}$ m. A first-order bright band appears 13.2 mm from the central bright band on a screen 0.600 m from the slits. What is λ?

$$\lambda = \frac{xd}{L}$$

$$\lambda = \frac{(13.2 \times 10^{-3})(1.9 \times 10^{-5})}{(0.6)}$$

$$\lambda = 4.18 \times 10^{-7} m$$

**2.** Yellow-orange light from a sodium lamp of wavelength 596 nm is aimed at two slits that are separated by $1.90 \times 10^{-5}$ m. What is the distance from the central band to the first-order yellow band if the screen is 0.600 m from the slits?

$$\lambda = \frac{xd}{L}$$

$$596 \times 10^{-9} = \frac{x(1.9 \times 10^{-5})}{(0.6)}$$

$$x = \frac{(596 \times 10^{-9})(0.6)}{(1.9 \times 10^{-5})} = 0.0188\, m$$

| | | | |
|---|---|---|---|
| Q4 | 1. Apply the relation (λ=xd/L) to calculate the wavelength or to find an unknown distance in a double-slit investigation given the other values.<br>2. Show that the intensity of bright bands decreases as you go farther from the central band (double slit interference with monochromatic light).<br>3. Explain the formation of a colored spectra when white light is used in a double-slit investigation.<br>4. Solve problems on interference of light. | Student Book | 193-196 |
| | | Example Problem 1, Q.1-Q.4;<br>Example Problem 2, Q.5-Q.9 | 196; 197-200; 199 |

**3.** In a double-slit investigation, physics students use a laser with λ = 632.8 nm. A student places the screen 1.000 m from the slits and finds the first-order bright band 65.5 mm from the central line. What is the slit separation?

$$\lambda = \frac{xd}{L}$$

$$632.8 \times 10^{-9} = \frac{(65.5 \times 10^{-3})d}{(1)}$$

$$d = \frac{(632.8 \times 10^{-9})(1)}{(65.5 \times 10^{-3})} = 9.66 \times 10^{-6} m$$

**4. CHALLENGE** Yellow-orange light with a wavelength of 596 nm passes through two slits that are separated by $2.25 \times 10^{-5}$ m and makes an interference pattern on a screen. If the distance from the central line to the first-order yellow band is $2.00 \times 10^{-2}$ m , how far is the screen from the slits?

$$\lambda = \frac{xd}{L}$$

$$596 \times 10^{-9} = \frac{(2 \times 10^{-2})(2.25 \times 10^{-5})}{L}$$

$$L = \frac{(2 \times 10^{-2})(2.25 \times 10^{-5})}{(596 \times 10^{-9})} = 0.755 m$$

| | | | |
|---|---|---|---|
| Q4 | 1. Apply the relation (λ=xd/L) to calculate the wavelength or to find an unknown distance in a double-slit investigation given the other values.<br>2. Show that the intensity of bright bands decreases as you go farther from the central band (double slit interference with monochromatic light).<br>3. Explain the formation of a colored spectra when white light is used in a double-slit investigation.<br>4. Solve problems on interference of light. | Student Book | 193-196 |
| | | Example Problem 1, Q.1-Q.4; Example Problem 2, Q.5-Q.9 | 196; 197-200; 199 |

# Interference of Coherent Light:

## Young, double slit experiment:

The overlapping light from the two slits fell on an observing screen.

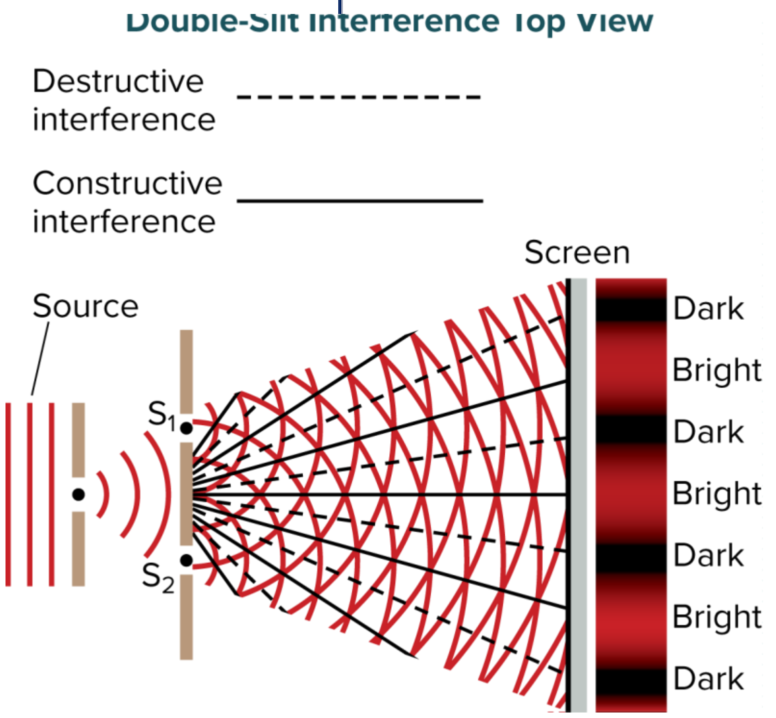
The overlap created a pattern of bright and dark bands called **interference fringes.**

- Constructive interference produces a bright central band of the given color on the screen, as well as other bright bands of near-equal spacing and near-equal width on either side, as shown in **Figure 3.**

- The intensity of the bright bands decreases the farther the band is from the central band, as you can see.

- Between the bright bands are dark areas where destructive interference occurs.

- The positions of the constructive and destructive interference bands depend on the light's wavelength.



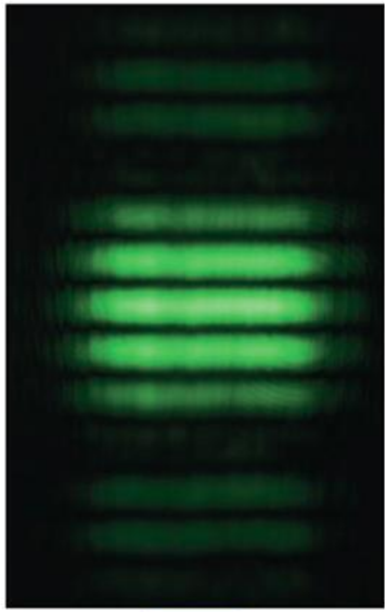
| Q4 | 1. Apply the relation (λ=xd/L) to calculate the wavelength or to find an unknown distance in a double-slit investigation given the other values.<br>2. Show that the intensity of bright bands decreases as you go farther from the central band (double slit interference with monochromatic light).<br>3. Explain the formation of a colored spectra when white light is used in a double-slit investigation.<br>4. Solve problems on interference of light. | Student Book | 193-196 |
|---|---|---|---|
| | | Example Problem 1, Q.1-Q.4;<br>Example Problem 2, Q.5-Q.9 | 196; 197-200; 199 |

## Interference of Coherent Light:

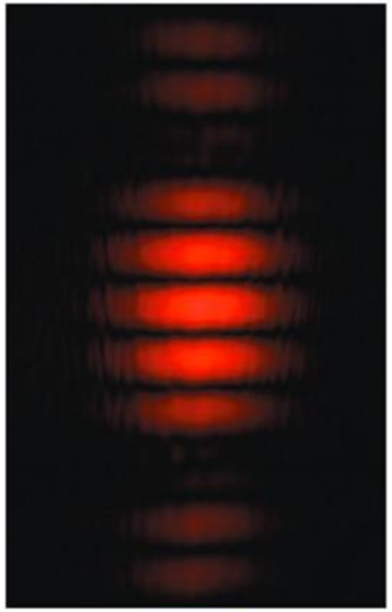
### What happens when a white light is used in a double-slit investigation?

- The interference causes the appearance of colored spectra.
- The various bands of color from the visible spectrum overlap on the screen. All these colors have constructive interference, and the central band is white.

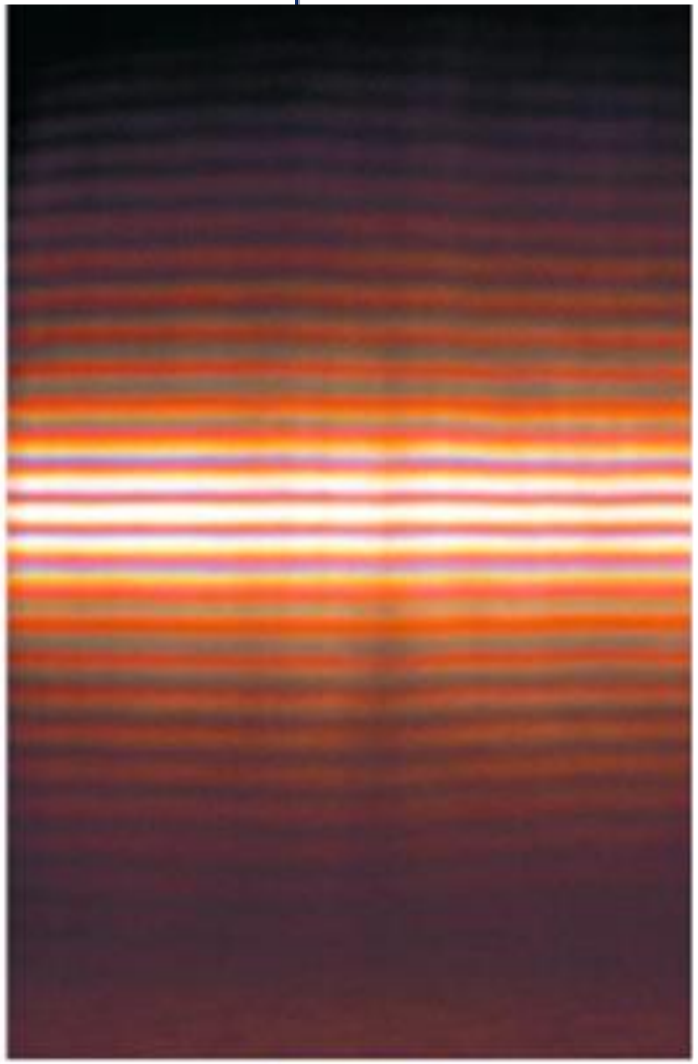
- Because the positions of the other bright bands of constructive interference depend on wavelength, each color's band is at a different position, resulting in spectra of color.



Green Light



Red Light



White Light

| Q4 | 1. Apply the relation (λ=xd/L) to calculate the wavelength or to find an unknown distance in a double-slit investigation given the other values.<br>2. Show that the intensity of bright bands decreases as you go farther from the central band (double slit interference with monochromatic light).<br>3. Explain the formation of a colored spectra when white light is used in a double-slit investigation.<br>4. Solve problems on interference of light. | Student Book | 193-196 |
|---|---|---|---|
| | | Example Problem 1, Q.1-Q.4;<br>Example Problem 2, Q.5-Q.9 | 196; 197-200; 199 |

## Example problem (page 200)

**OIL AND WATER** You observe colored rings on a puddle and conclude that there must be an oil slick on the water. You look directly down at the puddle and see a yellow-green (λ = 555 nm) region. If the refractive index of oil is 1.45 and that of water is 1.33, what is the minimum thickness of oil that could cause this color?

$$2d = \left(m + \frac{1}{2}\right)\lambda_{film}$$

Because $n_{oil} > n_{Air}$, the wave is inverted on the first reflection.

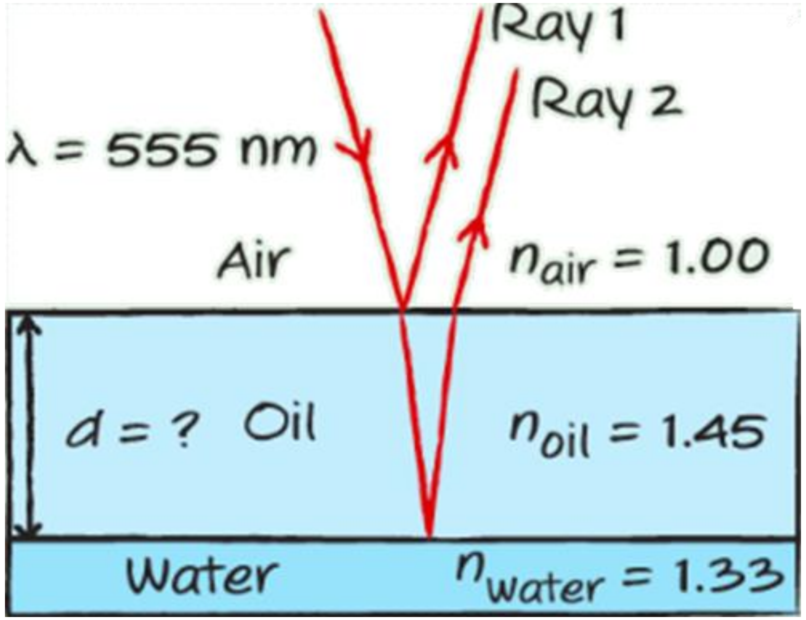
$$2d = \left(m + \frac{1}{2}\right)\frac{\lambda_{vacum}}{n_{oil}}$$

Because $n_{water} < n_{oil}$, there is no inversion on the second reflection. Thus, there is one wave inversion. The wavelength in oil is less than it is in air.

$$d = \frac{\lambda_{vacum}}{4n_{oil}}$$

Because you want the minimum thickness, m = 0.

$$d = \frac{555 \times 10^{-9}}{4(1.45)} = 95.7 \times 10^{-9}\ m$$



| | | | |
|---|---|---|---|
| Q4 | 1. Apply the relation (λ=xd/L) to calculate the wavelength or to find an unknown distance in a double-slit investigation given the other values.<br>2. Show that the intensity of bright bands decreases as you go farther from the central band (double slit interference with monochromatic light).<br>3. Explain the formation of a colored spectra when white light is used in a double-slit investigation.<br>4. Solve problems on interference of light. | Student Book | 193-196 |
| | | Example Problem 1, Q.1-Q.4;<br>Example Problem 2, Q.5-Q.9 | 196; 197-200; 199 |

**5.** In the situation in Example Problem 2, what would be the thinnest film that would create a reflected red (λ = 635 nm) band?

$$2d = \left(m + \frac{1}{2}\right)\lambda_{film}$$

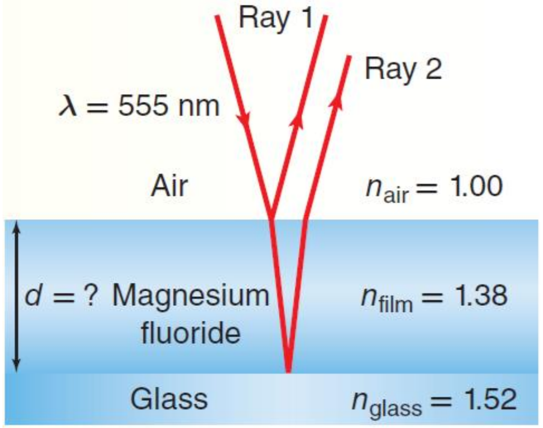
Because you want the minimum thickness, *m* = 0.

$$2d = \left(m + \frac{1}{2}\right)\frac{\lambda_{vacum}}{n_{oil}}$$

$$d = \frac{\lambda_{vacum}}{4n_{oil}}$$

$$d = \frac{635 \times 10^{-9}}{4(1.45)} = 1.09 \times 10^{-7}\ m$$

**6.** A glass lens has a nonreflective coating of magnesium fluoride placed on it. How thick should the nonreflective layer be to keep yellow-green light with a wavelength of 555 nm from being reflected? See the sketch in Figure 9.




$$2d = \left(m + \frac{1}{2}\right)\lambda_{film}$$

$$2d = \left(m + \frac{1}{2}\right)\frac{\lambda_{vacum}}{n_{film}}$$

$$d = \frac{\lambda_{vacum}}{4n_{film}}$$

$$d = \frac{555 \times 10^{-9}}{4(1.38)} = 1.01 \times 10^{-7}\ m$$

Because $n_{film} > n_{Air}$ and $n_{glass} > n_{film}$ there is a phase inversion on both the first and second reflections. For destructive interference to keep yellow-green from being reflected.

| | | | |
|---|---|---|---|
| Q4 | 1. Apply the relation (λ=xd/L) to calculate the wavelength or to find an unknown distance in a double-slit investigation given the other values.<br>2. Show that the intensity of bright bands decreases as you go farther from the central band (double slit interference with monochromatic light).<br>3. Explain the formation of a colored spectra when white light is used in a double-slit investigation.<br>4. Solve problems on interference of light. | Student Book | 193-196 |
| | | Example Problem 1, Q.1-Q.4;<br>Example Problem 2, Q.5-Q.9 | 196; 197-200; 199 |

**7.** You can observe thin-film interference by dipping a bubble wand into some bubble solution and holding the wand in the air. What is the thickness of the thinnest soap film at which you would see a black stripe if the light illuminating the film has a wavelength of 521 nm? Use n = 1.33 for the bubble solution.

Because $n_{film} > n_{Air}$ there is a phase change on the first reflection.
Because $n_{Air} < n_{film}$ there is no phase change on the second reflection.
For destructive interference to get a black stripe

$$2d = \frac{m\lambda}{n_{film}}$$

Because you want the minimum thickness, $m = 1$.

$$d = \frac{521 \times 10^{-9}}{2(1.33)} = 1.96 \times 10^{-7}\ m$$

**8.** What is the thinnest soap film (n = 1.33) for which light of wavelength 521 nm will constructively interfere with itself?

$$2d = \left(m + \frac{1}{2}\right)\lambda_{film}$$

For Constructive interference

$$2d = \left(m + \frac{1}{2}\right)\frac{\lambda_{vacum}}{n_{film}}$$

$$d = \frac{\lambda_{vacum}}{4n_{film}}$$

$$d = \frac{521 \times 10^{-9}}{4(1.33)} = 97.9 \times 10^{-9}\ m$$

| | | | |
|---|---|---|---|
| Q4 | 1. Apply the relation (λ=xd/L) to calculate the wavelength or to find an unknown distance in a double-slit investigation given the other values.<br>2. Show that the intensity of bright bands decreases as you go farther from the central band (double slit interference with monochromatic light).<br>3. Explain the formation of a colored spectra when white light is used in a double-slit investigation.<br>4. Solve problems on interference of light. | Student Book | 193-196 |
| | | Example Problem 1, Q.1-Q.4;<br>Example Problem 2, Q.5-Q.9 | 196; 197-200; 199 |

**9. CHALLENGE** A silicon solar cell has a nonreflective coating placed on it. If a film of silicon monoxide, n = 1.45, is placed on the silicon, n = 3.5, how thick should the layer be to keep yellow-green light (λ = 555 nm) from being reflected?

Because $n_{film} > n_{Air}$ there is a phase inversion on the first reflection.
Because $n_{silicon} < n_{film}$ there is a phase inversion on the second reflection.
For destructive interference to keep yellow-green from being reflected.

$$2d = \left(m + \frac{1}{2}\right)\lambda_{film}$$

$$2d = \left(m + \frac{1}{2}\right)\frac{\lambda_{vacum}}{n_{film}}$$

$$d = \frac{\lambda_{vacum}}{4n_{film}}$$

Because you want the minimum thickness, *m* = 0.

$$d = \frac{555 \times 10^{-9}}{4(1.45)} = 95.7 \times 10^{-9}\ m$$