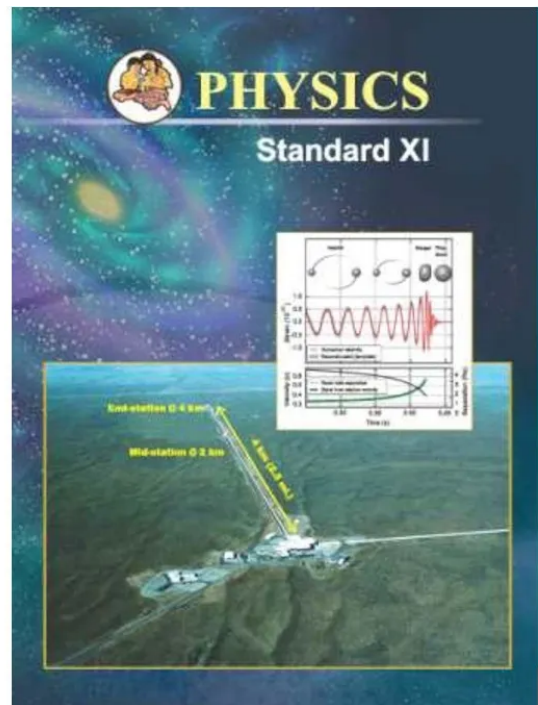


Maharashtra Board Solutions Class 11-Physics: Chapter 11- Electric Current Through Conductors

Class 11 - Chapter 11 Electric Current Through Conductors



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Maharashtra Board Solutions Class 11-Physics: Chapter 11- Electric Current Through Conductors

Class 11: Physics Chapter 11 solutions. Complete Class 11 Physics Chapter 11 Notes.

Maharashtra Board Solutions Class 11-Physics: Chapter 11- Electric Current Through Conductors

Maharashtra Board 11th Physics Chapter 11, Class 11 Physics Chapter 11 solutions

1. Choose the correct Alternative.

Question 1.

You are given four bulbs of 25 W, 40 W, 60 W, and 100 W of power, all operating at 230 V. Which of them has the lowest resistance?

- (A) 25 W
- (B) 40 W
- (C) 60 W
- (D) 100 W

Answer:

- (D) 100 W

Question 2.

Which of the following is an ohmic conductor?

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- (A) transistor
- (B) vacuum tube
- (C) electrolyte
- (D) nichrome wire

Answer:

- (D) nichrome wire

Question 3.

A rheostat is used

- (A) to bring on a known change of resistance in the circuit to alter the current.
- (B) to continuously change the resistance in any arbitrary manner and there by alter the current.
- (C) to make and break the circuit at any instant.
- (D) neither to alter the resistance nor the current.

Answer:

- (B) to continuously change the resistance in any arbitrary manner and there by alter the current.

Question 4.

The wire of length L and resistance R is stretched so that its radius of cross-section is halved. What is its new resistance?

- (A) $5R$
- (B) $8R$
- (C) $4R$

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(D) 16R

Answer:

(D) 16R

Question 5.

Masses of three pieces of wires made of the same metal are in the ratio 1 : 3 : 5 and their lengths are in the ratio 5 : 3 : 1. The ratios of their resistances are

(A) 1 : 3 : 5

(B) 5 : 3 : 1

(C) 1 : 15 : 125

(D) 125 : 15 : 1

Answer:

(D) 125 : 15 : 1

Question 6.

The internal resistance of a cell of emf 2 V is 0.1 Ω , it is connected to a resistance of 0.9 Ω . The voltage across the cell will be

(A) 0.5 V

(B) 1.8 V

(C) 1.95 V

(D) 3V

Answer:

(B) 1.8 V

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Question 7.

100 cells each of emf 5 V and internal resistance 1Ω are to be arranged so as to produce maximum current in a 25Ω resistance. Each row contains equal number of cells. The number of rows should be

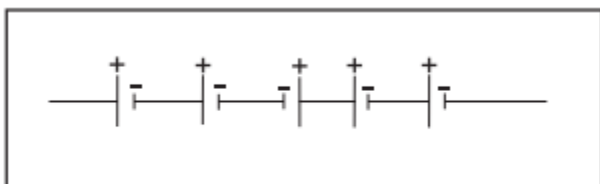
- (A) 2
- (B) 4
- (C) 5
- (D) 100

Answer:

- (A) 2

Question 8.

Five dry cells each of voltage 1.5 V are connected as shown in diagram



What is the overall voltage with this arrangement?

- (A) 0 V
- (B) 4.5 V
- (C) 6.0 V
- (D) 7.5 V

Answer:

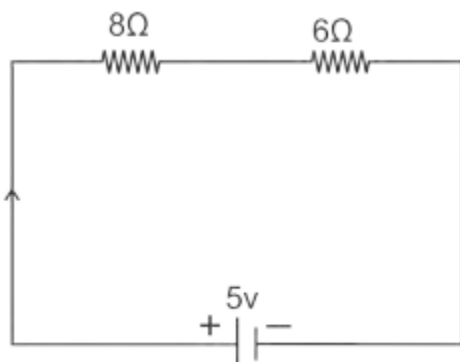
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(B) 4.5 V

2. Give reasons / short answers

Question 1.

In given circuit diagram two resistors are connected to a 5V supply.



- i. Calculate potential difference across the 8Ω resistor.
- ii. A third resistor is now connected in parallel with 6Ω resistor. Will the potential difference across the 8Ω resistor be larger, smaller or same as before? Explain the reason for your answer.

Answer:

Total current flowing through the circuit,

$$I = \frac{V}{R_s}$$

$$= \frac{5}{8+6}$$

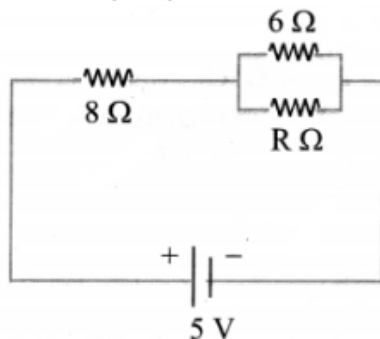
$$= \frac{5}{14} = 0.36 \text{ A}$$

$$\therefore \text{Potential difference across } 8 \Omega \text{ (V)} = 0.36 \times 8$$

$$= 2.88 \text{ V}$$

ii. Potential difference across 8Ω resistor will be larger.

Reason: As per question, the new circuit diagram will be



When any resistor is connected parallel to 6Ω resistance. Then the resistance across that branch (6Ω and $R \Omega$) will become less than 6Ω . i.e., equivalent resistance of the entire circuit will decrease and hence current will increase. Since, $V = IR$, the potential difference across 8Ω resistor will be larger.

Question 2.

Prove that the current density of a metallic conductor is directly proportional to the drift speed of electrons.

Answer:

i. Consider a part of conducting wire with its free electrons having the drift speed v_d in the direction opposite to the electric field E .

ii. All the electrons move with the same drift speed v_d and the current I is the same throughout the cross section (A) of the wire.

iii. Let L be the length of the wire and n be the number of free electrons per unit volume of the wire. Then the total number of free electrons in the length L of the conducting wire is nAL .

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iv. The total charge in the length L is,

$$q = nALe \dots\dots\dots (1)$$

where, e is the charge of electron.

v. Equation (1) is total charge that moves through any cross section of the wire in a certain time interval t.

$$\therefore t = \frac{L}{v_d} \dots\dots\dots (2)$$

vi. Current is given by,

$$I = \frac{q}{t} = \frac{nALe}{L/v_d} \dots\dots\dots [\text{From Equations (1) and (2)}]$$

$$= n Av_d e$$

Hence

$$v_d = \frac{1}{nAe}$$

$$= \frac{J}{ne} \dots\dots\dots (\because J = \frac{1}{A})$$

Hence for constant 'ne', current density of a metallic conductor is directly proportional to the drift speed of electrons, $J \propto v_d$.

3. Answer the following questions.

Question 1.

Distinguish between ohmic and non ohmic substances; explain with the help of example.

Answer:

Ohmic substances

1. Substances which obey ohm's law are called ohmic substances.
2. Potential difference (V) versus current (I) curve is a straight line.
3. Resistance of these substances is constant i.e. they follow linear I-V characteristic.

Non-ohmic substances

- Substances which do not obey ohm's law are called non-ohmic substances.
- Potential difference (V) versus current (I) curve is not a straight line.
 - Resistance of these substances

Expression for resistance is, $R = \frac{V}{I}$

Examples: Gold, silver, copper etc.

Expression for resistance is,
 $R = \lim_{\Delta I \rightarrow 0} \frac{\Delta V}{\Delta I} = \frac{dV}{dI}$

Examples: Liquid electrolytes, vacuum tubes, junction diodes, thermistors etc.

Question 2.

DC current flows in a metal piece of non uniform cross-section. Which of these quantities remains constant along the conductor: current, current density or drift speed?

Answer:

Drift velocity and current density will change as it depends upon area of cross-section whereas current will remain constant.

4. Solve the following problems.

Question 1.

What is the resistance of one of the rails of a railway track 20 km long at 20°C? The cross-section area of rail is 25 cm² and the rail is made of steel having resistivity at 20°C as $6 \times 10^{-8} \Omega \text{ m}$.

Answer:

Given: $l = 20 \text{ km} = 20 \times 10^3 \text{ m}$,

$A = 25 \text{ cm}^2 = 25 \times 10^{-4} \text{ m}^2$,

$\rho = 6 \times 10^{-8} \Omega \text{ m}$

To find: Resistance of rail (R)

Formula: $\rho = \frac{RA}{l}$

Calculation: From formula.

$$R = \rho \frac{l}{A}$$

$$\therefore R = \frac{6 \times 10^{-8} \times 20 \times 10^3}{A} = \frac{6 \times 4}{5} \times 10^{-1}$$

$$= 0.48 \Omega$$

Question 2.

A battery after a long use has an emf 24 V and an internal resistance 380 Ω . Calculate the maximum current drawn from the battery. Can this battery drive starting motor of car?

Answer:

$$E = 24 \text{ V}, r = 380 \Omega$$

i. Maximum current (I_{\max})

ii. Can battery start the motor?

$$\text{Formula: } I_{\max} = \frac{E}{r}$$

Calculation:

From formula,

$$I_{\max} = \frac{24}{380} = 0,063 \text{ A}$$

As, the value of current is very small compared to required current to run a starting motor of a car, this battery cannot be used to drive the motor.

Question 3.

A battery of emf 12 V and internal resistance 3 Ω is connected to a resistor. If the current in the circuit is 0.5 A,

- i. Calculate resistance of resistor.
- ii. Calculate terminal voltage of the battery when the circuit is closed.

Answer:

Given: $E = 12 \text{ V}$, $r = 3 \Omega$, $I = 0.5 \text{ A}$

To find:

- i. Resistance (R)
- ii. Terminal voltage (V)

Formulae:

i. $E = I (r + R)$

ii. $V = IR$

Calculation: From formula (i),

$$E = Ir + IR$$

$$\therefore R = \frac{E - Ir}{I}$$

$$= \frac{12 - 0.5 \times 3}{0.5}$$

$$= 21 \Omega$$

From formula (ii),

$$V = 0.5 \times 21$$

$$= 10.5 \text{ V}$$

Question 4.

The magnitude of current density in a copper wire is 500 A/cm². If the number of free electrons

per cm^3 of copper is 8.47×10^{22} , calculate the drift velocity of the electrons through the copper wire (charge on an $e = 1.6 \times 10^{-19} \text{ C}$)

Answer:

Given: $J = 500 \text{ A/cm}^2 = 500 \times 10^4 \text{ A/m}^2$,

$n = 8.47 \times 10^{22} \text{ electrons/cm}^3$

$= 8.47 \times 10^{28} \text{ electrons/m}^3$

$e = 1.6 \times 10^{-19} \text{ C}$

To Find: Drift velocity (v_d)

Formula: $v_d = \frac{J}{ne}$

Calculation:

From formula,

$$\begin{aligned} v_d &= \frac{500 \times 10^4}{8.47 \times 10^{28} \times 1.6 \times 10^{-19}} \\ &= \frac{500}{8.47 \times 1.6} \times 10^{-5} \\ &= \{\text{antilog} [\log 500 - \log 8.47 - \log 1.6]\} \times 10^{-5} \\ &= \{\text{antilog} [2.6990 - 0.9279 - 0.2041]\} \times 10^{-5} \\ &= \{\text{antilog} [1.5670]\} \times 10^{-5} \\ &= 3.690 \times 10^1 \times 10^{-5} \\ &= 3.69 \times 10^{-4} \text{ m/s} \end{aligned}$$

Question 5.

Three resistors 10Ω , 20Ω and 30Ω are connected in series combination.

i. Find equivalent resistance of series combination.

ii. When this series combination is connected to 12 V supply, by neglecting the value of internal resistance, obtain potential difference across each resistor.

Answer:

Given: $R_1 = 10 \Omega$, $R_2 = 20 \Omega$,

$$R_3 = 30 \, \Omega, V = 12 \, \text{V}$$

To Find: i. Series equivalent resistance (R_s)

ii. Potential difference across each resistor (V_1, V_2, V_3)

Formula: i. $R_s = R_1 + R_2 + R_3$

ii. $V = IR$

Calculation:

From formula (i),

$$R_s = 10 + 20 + 30 = 60 \, \Omega$$

From formula (ii),

$$I = \frac{V}{R} = \frac{12}{60} = 0.2 \, \text{A}$$

\therefore Potential difference across R_1 ,

$$V_1 = I \times R_1 = 0.2 \times 10 = 2 \, \text{V}$$

\therefore Potential difference across R_2 ,

$$V_2 = 0.2 \times 20 = 4 \, \text{V}$$

\therefore Potential difference across R_3 ,

$$V_3 = 0.2 \times 30 = 6 \, \text{V}$$

Question 6.

Two resistors $1\ \Omega$ and $2\ \Omega$ are connected in parallel combination.

i. Find equivalent resistance of parallel combination.

ii. When this parallel combination is connected to $9\ \text{V}$ supply, by neglecting internal resistance, calculate current through each resistor.

Answer:

$$R_1 = 1\ \text{k}\Omega = 10^3\ \Omega,$$

$$R_2 = 2\ \text{k}\Omega = 2 \times 10^3\ \Omega, V = 9\ \text{V}$$

To find:

i. Parallel equivalent resistance (R_p)

ii. Current through $1\ \text{k}\Omega$ and $2\ \text{k}\Omega$ (I_1 and I_2)

Formula:

$$\text{i. } \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\text{ii. } V = IR$$

Calculation: From formula (i),

$$\frac{1}{R_p} = \frac{1}{10^3} + \frac{1}{2 \times 10^3}$$

$$= \frac{3}{2 \times 10^3}$$

$$\therefore R^P = \frac{2 \times 10^3}{3} = 0.66\ \text{k}\Omega$$

From formula (ii),

$$I_1 = \frac{V}{R_1} = \frac{9}{10^3}$$

$$= 9 \times 10^{-3}\ \text{A}$$

$$= 9\ \text{mA}$$

$$I_2 = \frac{V}{R_2} = \frac{9}{2 \times 10^3}$$

$$= 4.5 \times 10^{-3}\ \text{A}$$

$$= 4.5\ \text{mA}$$

Question 7.

A silver wire has a resistance of 4.2Ω at 27°C and resistance 5.4Ω at 100°C . Determine the temperature coefficient of resistance.

Answer:

Given: $R_1 = 4.2 \Omega$, $R_2 = 5.4 \Omega$,

$T_1 = 27^\circ\text{C}$, $T_2 = 100^\circ\text{C}$

To find: Temperature coefficient of resistance (α)

$$\text{Formula: } \alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

Calculation:

From Formula

$$\alpha = \frac{5.4 - 4.2}{4.2(100 - 27)} = 3.91 \times 10^{-3}/^\circ\text{C}$$

Question 8.

A 6 m long wire has diameter 0.5 mm. Its resistance is 50Ω . Find the resistivity and conductivity.

Answer:

Given: $l = 6 \text{ m}$, $D = 0.5 \text{ mm}$,

$r = 0.25 \text{ mm} = 0.25 \times 10^{-3} \text{ m}$, $R = 50 \Omega$

To find:

- i. Resistivity (ρ)
- ii. Conductivity (σ)

Formulae:

$$\text{i. } \rho = \frac{RA}{l} = \frac{R\pi r^2}{l}$$

$$\text{ii. } \sigma = \frac{1}{\rho}$$

Calculation:

From formula (i),

$$\rho = \frac{50 \times 3.142 \times (0.25 \times 10^{-3})^2}{6}$$

$$= \{\text{antilog} [\log 50 + \log 3.142 + 2 \log 0.25 - \log 6]\} \times 10^{-6}$$

$$= \{\text{antilog} [1.6990 + 0.4972 + 2(1.3979) - 0.7782]\} \times 10^{-6}$$

$$= \{\text{antilog} [2.1962 + 2.7958 - 0.7782]\} \times 10^{-6}$$

$$= \{\text{antilog} [0.9920 - 0.7782]\} \times 10^{-6}$$

$$= \{\text{antilog} [0.2138]\} \times 10^{-6}$$

$$= 1.636 \times 10^{-6} \Omega/\text{m}$$

From formula (ii),

$$\sigma = \frac{1}{1.636 \times 10^{-6}}$$

$$= 0.6157 \times 10^6$$

....(Using reciprocal from log table)

$$= 6.157 \times 10^5 \text{ m}/\Omega$$

Question 9.

Find the value of resistances for the following colour code.

- Blue Green Red Gold
- Brown Black Red Silver
- Red Red Orange Gold
- Orange White Red Gold
- Yellow Violet Brown Silver

Answer:

i. Given: Blue – Green – Red – Gold

To find: Value of resistance

Formula: Value of resistance

$$= (xy \times 10^z \pm T\%) \Omega$$

Calculation:

Colour	Blue (x)	Green (y)	Red (z)	Gold (T%)
Code	6	5	2	± 5

From formula,

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Value of resistance = $(65 \times 10^2 \pm 5\%) \Omega$

Value of resistance = $6.5 \text{ k}\Omega \pm 5\%$

ii. Given: Brown – Black – Red – Silver

To find: Value of resistance

Formula: Value of resistance

= $(xy \times 10^z + T\%) \Omega$

Calculation:

Colour	Brown (x)	Black (y)	Red (z)	sliver (T%)
Code	1	0	2	± 10

From formula,

Value of resistance = $(10 \times 10^2 \pm 10\%) \Omega$

Value of resistance = $1.0 \text{ k}\Omega \pm 10\%$

iii. Given: Red – Red – Orange – Gold

To find: Value of the resistance

Formula: Value of the resistance

= $(xy \times 10^z \pm T\%)$

Calculation:

Colour	Red (x)	Red (y)	Orange (z)	Gold (T%)
--------	------------	------------	---------------	--------------

Code 2 2 3 ± 5

From formula,

$$\text{Value of resistance} = (22 \times 10^3 \pm 5\%) \Omega$$

$$\text{Value of resistance} = 22 \text{ k}\Omega \pm 5\%$$

[Note: The answer given above is presented considering correct order of magnitude.]

iv. Given: Orange – White – Red – Gold

To find: Value of the resistance

Formula: Value of the resistance

$$= (xy \times 10^z \pm T\%)$$

Calculation:

Colour	Ornage (x)	White (y)	Red (z)	Gold (T%)
Code	3	9	2	± 5

From formula,

$$\text{Value of resistance} = (39 \times 10^2 \pm 5\%) \Omega$$

$$\text{Value of resistance} = 3.9 \text{ k}\Omega \pm 5\%$$

v. Given: Yellow-Violet-Brown-Silver

To find: Value of the resistance

Formula: Value of the resistance

$$= (xy \times 10^z \pm T\%)$$

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Calculation:

Colour	Yellow (x)	violet (y)	Brown (z)	Sliver (T%)
Code	4	7	1	± 10

From formula,

$$\text{Value of resistance} = (47 \times 10 \pm 10\%) \Omega$$

$$\text{Value of resistance} = 470 \Omega \pm 10\%$$

[Note: The answer given above is presented considering correct order of magnitude.]

Question 10.

Find the colour code for the following value of resistor having tolerance $\pm 10\%$.

i. 330Ω

ii. 100Ω

iii. $47 \text{ k}\Omega$

iv. 160Ω

v. $1 \text{ k}\Omega$

Answer:

	Value of resistance	1 st Band	2 nd Band	Multiple	Tolerance	Colour code
i.	$330 \Omega \pm 10\%$ $= 33 \times 10^1 \Omega \pm 10\%$	3 (Orange)	3 (Orange)	10^1 (Brown)	$\pm 10\%$ (Silver)	Orange - Orange - Brown - Silver
ii.	$100 \Omega \pm 10\%$ $= 10 \times 10^1 \Omega \pm 10\%$	1 (Brown)	0 (Black)	10^1 (Brown)	$\pm 10\%$ (Silver)	Brown - Black - Brown - Silver
iii.	$47 \text{ k}\Omega \pm 10\%$ $= 47 \times 10^3 \Omega \pm 10\%$	4 (Yellow)	7 (Violet)	10^3 (Orange)	$\pm 10\%$ (Silver)	Yellow - Violet - Orange - Silver
iv.	$160 \Omega \pm 10\%$ $= 16 \times 10^1 \Omega \pm 10\%$	1 (Brown)	6 (Blue)	10^1 (Brown)	$\pm 10\%$ (Silver)	Brown - Blue - Brown - Silver
v.	$1 \text{ k}\Omega \pm 10\%$ $= 10 \times 10^2 \Omega \pm 10\%$	1 (Brown)	0 (Black)	10^2 (Red)	$\pm 10\%$ (Silver)	Brown - Black - Red - Silver

Question 11.

A current of 4 A flows through an automobile headlight. How many electrons flow through the headlight in a time of 2 hrs?

Answer:

Given: $I = 4 \text{ A}$, $t = 2 \text{ hrs} = 2 \times 60 \times 60 \text{ s}$

To find: Number of electrons (N)

Formula: $I = \frac{q}{t} = \frac{Ne}{t}$

Calculation: As we know, $e = 1.6 \times 10^{-19} \text{ C}$

From formula,

$$N = \frac{It}{e} = \frac{4 \times 2 \times 60 \times 60}{1.6 \times 10^{-19}} = 18 \times 10^{23}$$

Question 12.

The heating element connected to 230 V draws a current of 5 A. Determine the amount of heat dissipated in 1 hour ($J = 4.2 \text{ J/cal}$).

Answer:

Given: $V = 230 \text{ V}$, $I = 5 \text{ A}$,

$t = 1 \text{ hour} = 60 \times 60 \text{ sec}$

To find: Heat dissipated (H)

Formula: $H = \Delta U = I\Delta tV$

Calculation: From formula,

$$H = 5 \times 60 \times 60 \times 230$$

$$= 4.14 \times 10^6 \text{ J}$$

Heat dissipated in calorie,

$$H = \frac{4.14 \times 10^6}{4.2} = 985.7 \times 10^3 \text{ cal}$$

$$= 985.7 \text{ kcal}$$

Can you recall? (Textbook page no. 207)

An electric current in a metallic conductor such as a wire is due to the flow of electrons, the negatively charged particles in the wire. What is the role of the valence electrons which are the outermost electrons of an atom?

Answer:

- i. The valence electrons become de-localized when a large number of atoms come together in a metal.
- ii. These electrons become conduction electrons or free electrons constituting an electric current when a potential difference is applied across the conductor.

Internet my friend (Textbook page no. 218)

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<https://www.britannica.com/science/supercond> activity physics

[Students are expected to visit the above-mentioned website and Collect more information about superconductivity.]



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- Chapter 7- Thermal Properties of Matter
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The Maharashtra State Board of Secondary and Higher Secondary Education or MSBSHSE (Marathi: महाराष्ट्र राज्य माध्यमिक आणि उच्च माध्यमिक शिक्षण मंडळ), is an **autonomous and statutory body established in 1965**. The board was amended in the year 1977 under the provisions of the Maharashtra Act No. 41 of 1965.

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As of now, the MSCERT and Balbharti are responsible for the syllabus and textbooks of Classes 1 to 8, while Classes 9 and 10 are under the Maharashtra State Board of Secondary and Higher Secondary Education (MSBSHSE).

How many state boards are there in Maharashtra?

The Maharashtra State Board of Secondary & Higher Secondary Education, conducts the HSC and SSC Examinations in the state of Maharashtra through its nine Divisional Boards located at Pune, Mumbai, Aurangabad, Nasik, Kolhapur, Amravati, Latur, Nagpur and Ratnagiri.

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