4.6
CATHODE-RAY OSCILLOSCOPES

4.6 (a) **Cathode rays**

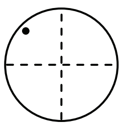
4.6 (b) **Simple treatment of cathode-ray oscilloscope**

4.6(a) Cathode-ray oscilloscopes

4.6(b) Simple treatment of cathode-ray oscilloscope

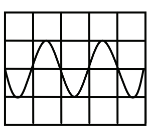
MCQs

1. A



When current (i.e. the electron beam) flows through the magnetic field acting downwards, it will be deflected according to Fleming's Left Hand Rule (i.e. to the left). The direction of low of electron is opposite to the flow of conventional current. The electron beam is negatively charged and hence will be attracted to the positively charged plate above and be deflected upwards. (ans)

2. D



Period of trace = $\frac{1}{f} = \frac{1}{50}$ = 0.02 s = 20 ms (ans)

3. C S

Let the voltage of the battery be v.

Voltage across X and Y = v × $\frac{6}{6+4}$ = 0.6v

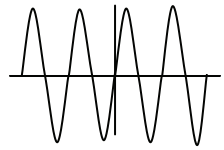
As such, the Y gain is 0.2v V per division.

Voltage across Z and Y = - v × $\frac{4}{6+4}$ = - 0.4v

Hence, the bright spot will be deflected to S. (ans)

4. D 50 Hz 4 V

5. D



Reducing the voltage gain from 2 V /cm to 1 V /cm increases the height of the trace. Increasing the time base from 10 μs /cm to 20 μs /cm reduces the width of one cycle of the trace. (ans)

6. A 4 V, 250 Hz

Period of the signal = $1.0 \times 10^{-3} \times 4 = 4 \times 10^{-3}$ s

Frequency of signal = $\frac{1}{T} = \frac{1}{4 \times 10^{-3}}$ = 250 Hz

Voltage of signal = 2.0 × 2 = 4 V (ans)

7. A Time base and gain control only

8. C Reading from oscilloscope,

Peak voltage = 20 V **(ans)**

Peak current = V / R = 20 V / 10 Ω = 2.0 A **(ans)**

9. C Y-gain = 2.8 V / 1.4 cm = 2.0 V/cm **(ans)**

Time-base = time / length

= T / 2.0 cm = (1/f) / 2.0 cm = (1/50)/2.0

= 0.01 s/cm = 10 ms/cm **(ans)**

10. A For E-field,

Electron deflect towards the positive end of the E-field, *i.e.*, upwards.

For B-field (magnetic field),

Electron deflect towards the left hand side of the B-field, *i.e.*, left (Fleming's left-hand rule).

The combined effect is towards 45° to the top left hand corner of the oscilloscope. **(ans)**

11. D To display on the oscilloscope,

Peak voltage = 5.0 V on a 5 V / div

= 1 division upwards (amplitude) (Y-gain) **(ans)**

Frequency = 50 Hz

Period = $1/f$ = 1/50 = 0.02 s = 20 ms

Time-base = 10 ms / div

Length of horizontal trace for one cycle

= 2 divisions **(ans)**

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12. C Initially, the Y-gain reading is 3 voltage-divisions upwards, *i.e.*, positively. Terminal T1 (location X) is positive compared to Terminal T2 (location Y).

Deduce that,

For each voltage division, it is taken up by 2 Ω resistance potential drop (6Ω/3=2div).

At the second Y-gain reading,

The resistance between Y and Z is 4 Ω.

Hence, the potential drop must be <u>2 divisions</u>.

Since the Terminal T1 is now negative as compared to Terminal T2, the trace will be <u>reversed</u>.

Answer: Point S **(ans)**

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13. D Reading from the trace,

Y-gain trace = 2 divisions = 2.0 V × 2

= 4 V (peak voltage) **(ans)**

Time-base trace (1 period)

= 4 divisions = 5 ms × 4 div = 20 ms

Frequency = 1 / T = 1 / 20 ms = 50 Hz **(ans)**

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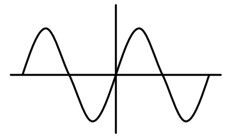
14. D Based on the original trace,

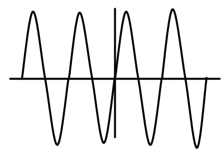


The voltage gain is changed from 2 V/cm to 1 V/cm and the time base is changed from 10 μs/cm to 20 μs /cm.

Y-gain is now more sensitive by double, the amplitude is changed to twice. **(ans)**

The time-base is now less sensitive by half, the period is now halved. **(ans)**

(D)



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15. A The time-base is set to 1.0 ms/div, and the voltage sensitivity is 2.0 V/div.

Peak voltage = 2 divisions = 2 × 2.0 V

= 4.0 V **(ans)**

Period = 4 divisions = 4 × 1.0 ms = 4.0 ms

Frequency = 1 / T = 1 / 4.0 ms = 250 Hz **(ans)**

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16. A The Y-gain of P must be amplified, *i.e.*, change Y-gain.

The time-base has to be amplified, *i.e.*, change the time base. **(ans)**

The focus, X-shift and Y-shift did not matter.

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17. D The a.c. supply is sinusoidal in nature, *i.e.*, the final trace must have sinusoidal curve-like features.

The diode does not allow current in reverse-biased to pass through, *i.e.*, only half of the sinusoidal wave can be detected. **(ans)**

Questions – 4.6(a) & (b)

1. (a)(i)

A high temperature is needed. It is done by heating a metal filament with a current or voltage. (ans)

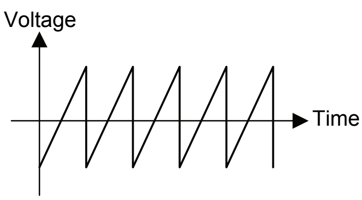
(a)(ii)

A high voltage across AE is needed. (ans)

(a)(iii)

By coating the screen with a fluorescent substance. (ans)

(b)(i)



(ans)

(b)(ii)

The spot moves at a constant speed across the screen. (ans)

(c)(i)

Alternating voltage. (ans)

(c)(ii)

Peak voltage = 10 × 0.8 = 8 V (ans)

2. (a)

Peak value of applied voltage = 2.0 × 2 = 4.0 V (ans)

(b)

Period of trace, T = 1.0 × 4 = 4.0 ms

Frequency of applied voltage

$= \frac{1}{T} = \frac{1}{4.0 \times 10^{-3}}$ = 250 Hz (ans)

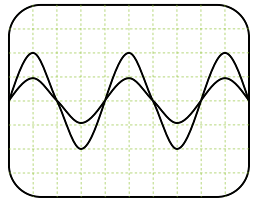
(c)

4.0 ms = time base setting × 2 cm

Time base setting = 2.0 ms/cm (ans)

(d)

1 cm × 1 cm squares



(ans)

3. (a)

Electrons. (ans)

(b)

To allow electrons to flow to earth so that it will not obstruct incoming electrons. (ans)

(c)

A time-base is an alternating saw-toothed voltage which controls the speed at which the electron sweeps across the screen. (ans)

(d)

Along OY (ans)

(e)

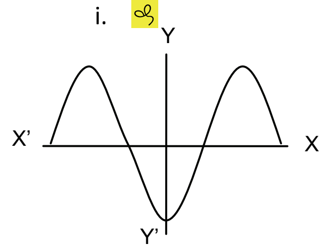
Along OX' (ans)

(f)

Plates B and C must be positively charged.

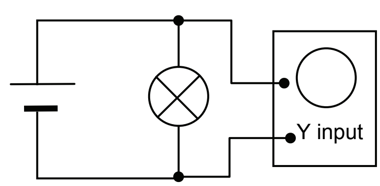
Plates A and D must be negatively charged. (ans)

(g) i.



(ans)

(h)



(ans)

4. (a)(i)

To heat the cathode. (ans)

(a)(ii)

To accelerate and focus the electron beam. (ans)

(a)(iii)

To allow the electrons to move unimpended. (ans)

(b)(i)

Current in tube = $\frac{Q}{t} = \frac{1.6\times10^{-19}\times2.4\times10^{14}}{12}$

= 3.2×10^{-6} A (ans)

(b)(ii)

Power conveyed by electron beam

= IV = $3.2 \times 10^{-6} \times 3.0 \times 10^{3} = 9.6 \times 10^{-3}$ W

(ans)

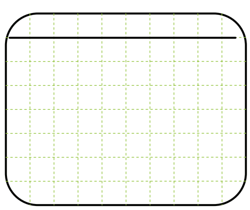
(b)(iii)

Kinetic energy carried by one electron

= $\frac{Pt}{no.\ of\ electrons} = \frac{9.6\times10^{-3}\times12}{2.4\times10^{14}}$

= 4.8×10^{-16} J (ans)

5. (a)(i)

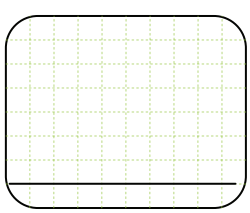


(ans)

(a)(ii)

The amplitude of the trace will be double. (ans)

(a)(iii)



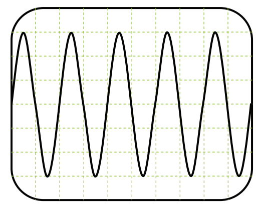
(ans)

(b)(i)

Period of trace = $\frac{1}{f} = \frac{1}{10}$ = 0.1 s = 100 ms

Horizontal distance for 1 cycle of a.c. displayed on screen = 100 ÷ 50 = 2 cm

Amplitude of the trace = 3 ÷ 1 = 3 cm



(ans)

(b)(ii)

As X slides towards A, the amplitude of the trace doubles while the frequency remains the same.
(ans)

Notes: