Chapter 10

Numerical

Book Work Examples

1. The given figure shows the displacement vs the time of a wave traveling to the right with a speed of 4 m/s.

(a) What is the time Period and frequency of the wave?

(b) Calculate the wavelength of the wave?

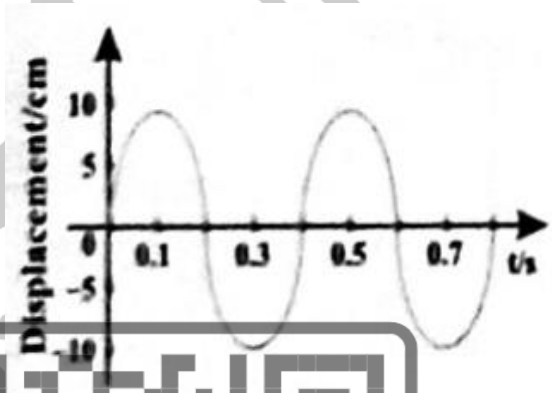
DATA

V = 4m/s

T = ?

f =?

λ = ?



SOLUTION

From figure

T = 0.4 sec

$f = \frac{1}{T}$

$f = \frac{1}{0.4}$

f = 2.5 Hz

V=fλ

4 = 2.5 λ

$\lambda = \frac{4}{2.5}$=1.6m

2. A fisherman notices that his boat is moving up and down regularly due to waves on the surface of the water. It takes 4.0s for the boat to travel from the highest to the lowest point, a total distance of 3.0 m. The fisherman sees that the wave crests are spaced 8.0 m apart.

(a) What is the period, frequency, amplitude, and wavelength of the waves?

(b) How fast are the waves moving?

DATA

t = 4 sec

Distance between the crest and the trough = 8m

Total distance = d =3m

T = ?

f = ?

A = ?

SOLUTION

T = 2t = 2 x 4 = 8 sec

f = $\frac{1}{T} = \frac{1}{8}$ = 0.125 Hz

A = $\frac{d}{2} = \frac{3}{2}$ = 1.5 m

Distance between the crest and the trough = λ = 8m

V=fλ

V=0.125 x 8

V = 1m/s

3. Find the period and frequency of a simple pendulum 1.0 m Simple Harmonic long at a location where g=9.8 ms^{-2}.

DATA

L = 1 m

π = 3.142

g = 9.8 m/s^2

T = ?

SOLUTION

T = $2\pi\sqrt{\frac{l}{g}}$

T = 2 x 3.142 $\sqrt{\frac{1}{9.8}}$

T= 6.284 $\sqrt{0.102}$

T = 6.284 x 0.319

T = 2 sec

4. Pendulum clocks with a pendulum measuring out the passing of a second. How long of a pendulum is
required to have a period of 1 second? g = 9.8 m/s^2.

DATA

T = 1 sec

π = 3.142

g = 9.8 m/s^2

L = ?

SOLUTION

L = $\frac{T^2 g}{4\pi^2}$

$L = \frac{1^2 \times 9.8}{4 \times 3.142^2}$

$L = \frac{9.8}{39.49}$

L = 0.248 m

Book Numerical

1. What is the wavelength of a radio wave broadcasted by a radio station with a frequency of 1300 kHz? Where 1K=10^3, and the speed of the radio-wave is 3x 10^8 m/s.

DATA

f = 1300Khz = 1300 x 1000 = 1.3 x 10^6

V = 3x 10^8 m/s

λ = ?

SOLUTION

V = fλ

3x 10^8 = 1.3 x 10^6 x λ

$\lambda = \frac{3 \times 10^8}{1.3 \times 10^6}$

λ = 2.304 x 10^2m

OR

λ = 230.4 m

2. The waves moving in the pond have a wavelength of 1.6 m, and a frequency of 0.80 Hz. Calculate the speed of these water waves.

DATA

λ = 1.6 m

f = 0.80 Hz

V = ?

SOLUTION

V = fλ

V = 0.80 x 1.6

V = 1.28 m/s

3. If 50 waves pass through a point in the rope in 10 seconds, what are the frequency and the period of the wave? If its wavelength is 8 cm, calculate the wave speed. Explain the type of wave produced.

DATA

50 waves in 10 sec

λ = 80 cm = $\frac{8}{100}$ = 0.08m

V = ?

f = ?

T = ?

SOLUTION

f = $\frac{waves}{time for\ waves} = \frac{50}{10}$ = 50Hz

T = $\frac{1}{f}$

T = $\frac{1}{50}$

T = 0.20 sec

V = fλ

V = 5 x 0.08

V = 0.40 m/s

4. A slinky has produced a longitudinal wave. The wave travels at a speed of 40 cm/s and the frequency of the wave is 20 Hz. What is the minimum separation between the consecutive compressions?

DATA

V= 40cm/s

f = 20Hz

λ = ?

SOLUTION

V = fλ

40 = 20 x λ

λ = $\frac{40}{20}$

λ = 2 cm

Or

λ = 0.02 m

5. Suppose a student is generating waves in a slinky. The student's hand makes one complete forth and back oscillation in 0.40 s. The wavelength in the slinky is 0.60m. For this wave, determine a. Period and frequency b. Wave speed

DATA

1 oscillation in 0.40 sec

λ = 0.6 m

T = ?

V = ?

SOLUTION

f = $\frac{\textbf{oscillation}}{\textit{time for}\ \textbf{oscillation}} = \frac{1}{0.40}$ = 2.5 Hz

T = $\frac{\mathbf{1}}{f}$

T = $\frac{1}{2.5}$

T = 0.40 sec

V = fλ

V = 2.5 x 0.6

V = 1.5 m/s

6. If 80 compressions pass through a point in spring in 20 seconds. Calculate the frequency and the period? If two consecutive compressions are 8 cm apart, calculate the wave speed.

DATA

80 compressions in 20 sce

λ = 8cm = $\frac{8}{100}$ =0.08 m

f = ?

T = ?

V = ?

SOLUTION

f = $\frac{\textbf{compressions}}{\textit{time for}\ \textbf{compressions}} = \frac{80}{20}$ = 4 Hz

T = $\frac{\mathbf{1}}{f}$

T = $\frac{1}{4}$

T = 0.25 sec

V = fλ

V = 4 x 0.08

V = 0.32 m/s

7. Waves on a swimming pool propagate at 0.90 m/s. If you splash the water at one end of the pool, observe the wave go to the opposite end, reflect, and return in 30.0 s. How far away is the other end of the pool?

DATA

V = 0.90 m/s

Time to travel and reflect = 30 sec

λ = ?

SOLUTION

One side time = $\frac{\textbf{Time to travel and reflect}}{\textbf{2}}$

T = $\frac{30}{2}$ = 15 sec

V = $\frac{\lambda}{T}$

0.90 x 15 = λ

λ = 13.5 m

8. A simple oscillating pendulum has a length of 80.0 cm. Calculate its a. Period b. Frequency When g = 9.8 m/s²

DATA

L = 80 cm = 0.8m

π = 3.142

g = 9.8 m/s²

T = ?

f = ?

SOLUTION

T = 2π $\sqrt{\frac{l}{g}}$

T = 2 x 3.142 $\sqrt{\frac{0.8}{9.8}}$

T= 6.284 $\sqrt{0.0816}$

T = 6.284 x 0.285

T = 1.795 sec

f = $\frac{\mathbf{1}}{\boldsymbol{T}}$

f = $\frac{1}{1.795}$

f = 0.557 Hz

Chapter # 11

Worked Example 1 **A sound wave has a frequency of 6 kHz and wave length 25cm. How long will it take to travel1.5 km?**

DATA

F = 6KHz = 6000 Hz

λ = 25 cm = 25/100 = 0.25m

T = ? when λ = 1.5km = 1500m

SOLUTION

V = fλ

V = 6000 x 0.25

V = 1500m/s

V= $\frac{\lambda}{T}$

1500= $\frac{1500}{T}$

T= $\frac{1500}{1500}$

T = 1 sec

Worked Example 2 **Calculate the speed of sound in air at 30°C? Given that Speed of sound at 0°C is 331** m/s.

T = 30°C = 30 +273=303 K

V at 0°C = 331m/s

V at 30°C = ?

SOLUTION

V = 331 $\sqrt{\frac{T}{273}}$

V = 331 $\sqrt{\frac{303}{273}}$

V = 331 $\sqrt{1.1098}$

V = 331 x 1.053

V = 348.71 m/s

Worked Example3 **A boy clapped his hands near a wall and heard the echo after 1.6 s. What is the distance of the wall from the boy if the speed of the sound, v is taken as 340 ms^{-1}.**

DATA

Echo = E = 1.6sec

V = 340 m/s

S = ?

SOLUTION

T = $\frac{E}{2} = \frac{1.6}{2}$ = 0.8 sec

V= $\frac{S}{t}$

340 = $\frac{S}{0.8}$

S = 340 x 0.8

S = 272 m

BOOK NUMERICALS

1. **Calculate the speed of sound in air at 50°C? Given that speed of sound at 0°C Is 331m/s.**

DATA

T = 50°C = 50 +273=323 K

V at 0°C = 331m/s

V at 50°C = ?

SOLUTION

V = 331 $\sqrt{\frac{T}{273}}$

V = 331 $\sqrt{\frac{323}{273}}$

V = 331 $\sqrt{1.183}$

V = 331 x 1.0876

V = 359.99 m/s

2. **A person has an audible range from 20 Hz to 20 kHz. What are the distinguishing wavelengths of sound waves in air corresponding to these two Frequencies? Take the speed of sound in air as 340 ms^{-1}**
   (58.8mm and 58.82m)

DATA

Audible range 20 Hz to 20 kHz

f_1 = 20 Hz

f_2 = 20 KHz = 20000 Hz

V = 340m/s

λ_1 = ?

λ_2 = ?

SOLUTION

$V = f_1\lambda_1$

$340 = 20\ \lambda_1$

$\lambda_1 = \frac{340}{20}$

$\lambda_1 = 17m$

$V = f_2\lambda_2$

$340 = 20000\ \lambda_2$

$\lambda_2 = \frac{340}{20000}$

$\lambda_2 = 0.017m$

3. A ship uses ultrasonic pulses to measure the depth of the submarine beneath the ship. A sound pulsing is transmitted into the sea, and the echo from the Sea-bed is received after 40 ms^{-1}. The speed of sound in seawater is 1480 m/s. Calculate the deepness of the submarine. (29.6 ≈ 30m)

DATA

E = 40 ms (mili sec)

V = 1480 m/s

S = ? (S= deepness)

SOLUTION

T = $\frac{E}{2} = \frac{40}{2}$ = 20 msec

T = $\frac{20}{1000}$ = 0.02 sec

V = $\frac{S}{t}$

$1480 = \frac{S}{0.02}$

S = 1480 x 0.02

S = 29.6 m

S = 30 m

4. At night, bats emit pulses of sound to detect their prey. The speed of sound in air is 340 m/s.

(i) A bat emits a pulse of the sound of wavelength 0.0080 m. Calculate the Frequency of the sound.

(ii) The pulse of sound hits its prey and is reflected in the bat. The bat receives The pulse 0.10 s after it is emitted. Calculate the distance traveled by the pulse of sound during this time.

(iii) Calculate the distance of prey from the bat.

DATA

V = 340 m/s

(i) $\lambda = 0.008$ m

f = ?

SOLUTION

V = fλ

340 = f x 0.008

F = $\frac{340}{0.008}$ = 42500 Hz

(ii) E = 0.1 sec

S = ?

For distance of pulse we use echo. So

V = $\frac{S}{E}$

340 = $\frac{S}{0.01}$

S = 340 x 0.01

S = 34m

(iii) d = ? (Distance of prey from the bat)

d = $\frac{S}{2}$ = $\frac{34}{2}$ = 17m

Chapter # 12

Worked Example 1

Ruby laser emits the beam of red light having a wavelength of 694.3 nm. Calculate its frequency.

DATA

λ -= 694.3 nm = 694.3 x 10^{-9} m

V = C = 3 x 10^{8} m/s

f = ?

SOLUTION

c = fλ

3 x 10^{8} = f x 694.3 x 10^{-9}

F = $\frac{3\times10^{8}}{694.3\times10^{-9}}$

F = 0.00432 x 10^{8+9}

F = 0.00432 x 10^{17}

F = 4.32 x 10^{17-3}

F = 4.32 x 10^{14} Hz

Book Numerical

1. Electromagnetic radiation having a 15.0 μm wavelength is classified as infrared radiation. What is its frequency? Given that the speed of light is 3x10^{8} m/s.

DATA

λ = 15 μm = 15 x 10^{-6} m

C = 3 x 10^{8} m/s

f = ?

SOLUTION

c = fλ

3 x 10^{8} = f x 15 x 10^{-6}

f = $\frac{3\times10^{8}}{15\times10^{-6}}$

f = 0.2 x 10^{8+6}

f = 0.2 x 10^{14} Hz

2. What is the frequency of the 193-nm ultraviolet radiation used in laser eye surgery?

DATA

λ = 193 nm = 193 x 10^{-9} m

C = 3 x 10^{8} m/s

f = ?

SOLUTION

c = fλ

$3 \times 10^8 = f \times 193 \times 10^{-9}$

$f = \frac{3\times10^8}{193\times10^{-9}}$

$f = 0.015 \times 10^{8+9}$

$f = 0.015 \times 10^{17}$ Hz

OR

$f = 15 \times 10^{17-3}$

$f = 15 \times 10^{14}$ Hz

3. Calculate the wavelength of 100-MHz radio waves used in an MRI unit?

DATA

f= 100 MHz = 100×10^6 Hz

C = 3×10^8 m/s

λ = ?

SOLUTION

c= fλ

$3 \times 10^8 = \lambda \times 100 \times 10^6$

$\lambda = \frac{3\times10^8}{100\times10^6}$

$\lambda = 0.03 \times 10^{8-6}$

$\lambda = 0.03 \times 10^2$

$\lambda = 3 \times 10^{2-2}$

$\lambda = 3$ m

4. The distance from earth to sun is 1.49×10^{11} meters. How long a radio pulse radiated from the sun takes to reach on the earth?

DATA

s = 1.49×10^{11} m

c = 3×10^8 m/s

T = ?

SOLUTION

c= $\frac{S}{T}$

$3 \times 10^8 = \frac{1.49\times10^{11}}{T}$

$T = \frac{1.49\times10^{11}}{3\times10^8}$

$T = 0.4966 \times 10^{11-8}$

$T = 0.4966 \times 10^3$

T = 496.6 sec

5. Distances in space are often measured in units of light-years, the distance light travels in one year. Find the distance in kilometres in a light-year?

DATA

S = ?

T = 1year = 365 x 24x 60 x 60

T = 31536000 sec

c = 3 x 10^8 m/s

SOLUTION

c= $\frac{S}{T}$

3 x 10^8 = $\frac{S}{31536000}$

S = 3 x 10^8 x 31536000

S = 94608000 x 10^8 m

m → km (÷ 1000 or x 10^{-3})

S = 94608000 x 10^8 x 10^{-3}

S = 94608000 x 10^5

S = 9.4608 x 10^{5+7}

S = 9.4608 x 10^{12} km

6. What is the frequency of green light with a wavelength of 5.5 x 10^{-7}m?

DATA

λ = 5.5 x 10^{-7} m

C = 3 x 10^8 m/s

f = ?

SOLUTION

c = fλ

3 x 10^8 = f x 5.5 x 10^{-7}

f = $\frac{3\times10^8}{5.5\times10^{-7}}$

f = 0.5454 x 10^{8+7}

f = 0.5454 x 10^{15} Hz

OR

f = 5.454 x 10^{14} Hz

7. A typical household microwave oven operates at a frequency of 2.45-GHz What is the wavelength of this radiation?

DATA

f= 2.45 GHz = 2.45 x 10^9 Hz

C = 3 x 10^8 m/s

λ = ?

SOLUTION

c = fλ

$3 \times 10^8 = \lambda \times 100 \times 10^6$

$\lambda = \frac{3\times10^8}{2.45\times10^9}$

$\lambda = 1.22 \times 10^{8-9}$

$\lambda = 1.22 \times 10^{-1}$

Or

$\lambda = 0.122$ m

Chapter 13

Worked Example 1

A concave mirror forms a real image at 25.0 cm from the mirror surface along the principal axis. If the corresponding object is at a 10.0 cm distance, what is the focal length of the mirror?

DATA

q = 25 cm

p = 10 cm

f = ?

SOLUTION

$$\frac{\mathbf{1}}{\boldsymbol{f}} = \frac{\mathbf{1}}{\boldsymbol{p}} + \frac{\mathbf{1}}{\boldsymbol{q}}$$

$$\frac{1}{f} = \frac{1}{10} + \frac{1}{25}$$

$$\frac{1}{f} = \frac{25 + 10}{250}$$

$$\frac{1}{f} = \frac{35}{250}$$

$$f = \frac{250}{35}$$

f = 7.142 cm

Worked Example 2

DATA

The refractive index of the diamond is 2.42. What is the speed of light in a diamond?

n = 2.42

V = ?

c = 3 x 10^8 m/s

SOLUTION

$\mathbf{n} = \frac{\boldsymbol{c}}{\boldsymbol{V}}$

$2.42 = \frac{3\times10^8}{V}$

$V = \frac{3\times10^8}{2.42}$

V = 1.239 x 10^8 m/s

Worked Example 3

Calculate the value of critical angle for water refracted angle at 90°. The retractive index of water is 1.33.

DATA

n = 1.33

$\angle i = 90^o$

$\angle r = \angle c = ?$

SOLUTION

$$\mathbf{n = \frac{\sin \angle i}{\sin \angle c}}$$

$$1.33 = \frac{\sin 90}{\sin \angle c}$$

$$\sin \angle c = \frac{1}{1.33}$$

$$\angle c = \sin^{-1}(0.751)$$

$$\angle c = 54.08^o$$

Worked Example 4

A boy is standing 2.500 m in front of a camera. The camera uses a convex lens whose focal Length is 0.050 m. Find the image distance (the distance between the lens and the film and determine whether the image is real or virtual. Also, find the power of the lens.

DATA

p = 2.5m

f = 0.05 m

q = ?

Nature = ?

P(Power) = ?

SOLUTION

$$\frac{\mathbf{1}}{\boldsymbol{f}} = \frac{\mathbf{1}}{\boldsymbol{p}} + \frac{\mathbf{1}}{\boldsymbol{q}}$$

$$\frac{1}{0.05} = \frac{1}{2.5} + \frac{1}{q}$$

$$\frac{1}{0.05} - \frac{1}{2.5} = \frac{1}{q}$$

$$\frac{1}{q} = \frac{2.5 - 0.05}{0.125}$$

$$\frac{1}{q} = \frac{2.45}{0.125}$$

$$q = \frac{0.125}{2.45}$$

q = 0.051 m

Nature = real (q is positive)

$$P = \frac{1}{f}$$

$$P = \frac{1}{0.05}$$

p = 20diopter

Book Numerical

1. A thumb pin is positioned at a distance of 15 cm from a convex mirror of a focal length of 20 cm. Determine the position and nature of the image.

p = 15 cm

f = –20cm (convex mirror)

q = ?

SOLUTION

$$\frac{\mathbf{1}}{\boldsymbol{f}} = \frac{\mathbf{1}}{\boldsymbol{p}} + \frac{\mathbf{1}}{\boldsymbol{q}}$$

$$\frac{1}{-20} = \frac{1}{15} + \frac{1}{q}$$

$$-\frac{1}{20} - \frac{1}{15} = \frac{1}{q}$$

$$\frac{1}{q} = \frac{-15 - 20}{300}$$

$$\frac{1}{q} = \frac{-35}{300}$$

$$q = -\frac{300}{35}$$

q = –8.57 cm

2. An image of a specimen appears to be 11.5 cm behind a concave mirror with a focal length of 13.5 cm. Find the specimen's distance from the mirror.

DATA

f = 13.5 cm (concave lens f +)

q = –11.5 cm (behind the mirror is virtual, so q is negative)

p = ?

SOLUTION

$$\frac{\mathbf{1}}{\boldsymbol{f}} = \frac{\mathbf{1}}{\boldsymbol{p}} + \frac{\mathbf{1}}{\boldsymbol{q}}$$

$$\frac{1}{13.5} = \frac{1}{p} + \frac{1}{-11.5}$$

$$\frac{1}{13.5} + \frac{1}{11.5} = \frac{1}{p}$$

$$\frac{1}{p} = \frac{11.5 + 13.5}{155.25}$$

$$\frac{1}{p} = \frac{25}{155.25}$$

$$p = \frac{155.25}{25}$$

p = 6.21 cm

3. A convex mirror used for rear-view on an automobile has a radius of curvature of 4.00 m. If a bus is located at 5.00 m from this mirror, find the image's position, nature, and size. (1.428m)

DATA

R = 4m

p = 5m

q = ?

nature

SOLUTION

f = $\frac{R}{2} = \frac{4}{2}$ = 2m

f = –2m (convex mirror f is negative)

$$\frac{\mathbf{1}}{\boldsymbol{f}} = \frac{\mathbf{1}}{\boldsymbol{p}} + \frac{\mathbf{1}}{\boldsymbol{q}}$$

$$\frac{1}{-2} = \frac{1}{5} + \frac{1}{q}$$

$$-\frac{1}{2} - \frac{1}{5} = \frac{1}{q}$$

$$\frac{1}{q} = \frac{-2-5}{10}$$

$$\frac{1}{q} = \frac{-7}{10}$$

$$q = -\frac{10}{7}$$

q = –1.428 cm

Nature = Virtual image formed

4. An object is placed 15 cm away from a converging lens of a focal length of 10 cm. Determine the position, size, and nature of the image formed. (2cm)

DATA

p = 15cm

f = 10 cm (converging lens is convex lens, so f = +)

q = ?

nature = ?

SOLUTION

$$\frac{\mathbf{1}}{\boldsymbol{f}} = \frac{\mathbf{1}}{\boldsymbol{p}} + \frac{\mathbf{1}}{\boldsymbol{q}}$$

$$\frac{1}{10} = \frac{1}{15} + \frac{1}{q}$$
$$\frac{1}{q} = \frac{1}{10} - \frac{1}{15}$$
$$\frac{1}{q} = \frac{15 - 10}{150}$$
$$\frac{1}{q} = \frac{5}{150}$$
$$q = \frac{150}{5}$$

q = 30 cm

Nature = real image

5. A concave lens of focal length 20 cm forms an image 15 cm from the lens. Determine the power of a lens. Also, how far is the object positioned from the lens? (0.05cm)

DATA

f = 20 cm (concave lens, f= –)

q = 15 cm

p = ?

P(power) = ?

SOLUTION

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$
$$-\frac{1}{20} = \frac{1}{p} + \frac{1}{15}$$
$$\frac{1}{p} = -\frac{1}{20} - \frac{1}{15}$$
$$\frac{1}{p} = \frac{-15 - 20}{300}$$
$$\frac{1}{p} = \frac{-35}{300}$$
$$p = -\frac{300}{35}$$

p = –8.57 cm

P = $\frac{100}{f}$(when f in cm)

P = $\frac{100}{20}$

p = 5 diopter

6. The angle of incidence for a ray of light from air to water interface is 40. If the ray travels through the water with a refractive index of 1.33, calculate the angle of refraction. (28.8°)

DATA

n = 1.33

$\angle i = 40^o$

$\angle r = ?$

SOLUTION

$n = \frac{\sin \angle i}{\sin \angle c}$

$1.33 = \frac{\sin 40}{\sin \angle c}$

$\sin \angle r = \frac{0.642}{1.33}$

$\angle r = \sin^{-1} (0.4419)$

$\angle r = 29.14^o$

CHAPTER # 14

Numerical

1. What is the electric force of repulsion between two electrons at a distance of 1m? (2.3 x 10^{-28} N)

DATA

Charge of electron

e = 1.6 x 10^{-19}C

r = 1m

K = 9 x10^9 Nm^2/C^2

F = ?

SOLUTION

F = $\frac{K\, q_1 q_2}{r^2}$ **q=e**

F = $\frac{K\, e_1 e_2}{r^2}$

F = $\frac{9\times10^9 \times1.67\times10^{-19}\times1.67\times10^{-19}}{1^2}$

F = 23.04 x 10^{-29}

F = 2.304 x 10^{-28}N

2. Two-point charges q_1 = 5μC and q_2 = 3 μC are placed at a distance of 5 cm. What will be the coulomb's force between them? (54 N)

q_1 = 5μC = 5 x 10^{-6}C

q_2 = 3μC = 2 x 10^{-6}C

r = 5 cm = 0.05m

K = 9 x10^9 Nm^2/C^2

F = ?

SOLUTION

F = $\frac{K q_1 q_2}{r^2}$

F = $\frac{9\times10^9 \times5\times10^{-6}\times3\times10^{-6}}{0.05^2}$

F = $\frac{135\times10^{-3}}{0.0025}$

F = 54000 x 10^{-3} N

OR

F = 54 N

3. If 2μC charge is placed in the field of 3.42 x 10^{11}N/C, what will be the force on it? (684 x 10^3 N)

DATA

q = 2μC = 2 x 10^{-6} C

E = 3.42 x 10^{11} N/C

F = ?

SOLUTION

E = $\frac{F}{q}$

3.42 x 10^{11} = $\frac{F}{2\times10^{-6}}$

F = 3.42 x 10^{11} x 2 x 10^{-6}

F = 6.84 x 10^5N

4. What is the charge on the capacitor, if a 40 μF capacitor has a potential difference of 6 V across it? (2.4 x 10^{-4})

DATA

C = 40μF = 40 x 10^{-6}F

V = 6 volts

q = ?

SOLUTION

q = CV

q = 40 x 10^{-6} x 6

q = 240 x 10^{-6}C

OR

q = 240μC

5. The potential difference between two points is 100 V. If an unknown charge is moved between thee points, the amount of work done is 500J. Find the amount of charge. (5 C)

DATA

V = 100 volts

W = 400J

q = ?

SOLUTION

q = $\frac{W}{V}$

q = $\frac{500}{100}$

q = 5C

6. Find the equivalent capacitance when a 4μF, 3 μF and 2 μF capacitor are connected in series. (0.92 μF)

DATA

C_1 = 4μF

C_1 = 3 μF

C_1 = 2 μF

C = ?

SOLUTION

Capacitors in series

$$\frac{\mathbf{1}}{\boldsymbol{C}} = \frac{\mathbf{1}}{\boldsymbol{C_1}} + \frac{\mathbf{1}}{\boldsymbol{C_2}} + \frac{\mathbf{1}}{\boldsymbol{C_3}}$$

$$\frac{1}{C} = \frac{1^{\times 3}}{4} + \frac{1^{\times 4}}{3} + \frac{1^{\times 6}}{2}$$

$$\frac{1}{C} = \frac{3+4+6}{12}$$

$$\frac{1}{C} = \frac{13}{12}$$

$C = \frac{12}{13}$

$C = 0.923\ \mu C$

Worked Example 1 Calculate the force of attraction between two point charge of +2mC and-3mC, if they apart of 1cm.

DATA

$q_1 = 2mC = 2 \times 10^{-3}\ C$

$q_2 = 3mC = 3 \times 10^{-3}\ C$

$r = 1cm = 0.01\ m$

$K = 9x\ 10^9\ Nm^2/C^2$

$F = ?$

SOLUTION

$$\mathbf{F} = \frac{\boldsymbol{K\, q_1 q_2}}{\boldsymbol{r^2}}$$

$$F = \frac{9\times10^9 \times 2\times10^{-3}\times3\times10^{-3}}{0.01^2}$$

$$F = \frac{54\times10^3}{0.0001}$$

$F = 540000 \times 10^3\ N$

$F = 5.4 \times 10^8\ N$

Worked Example 2 Calculate the electric field intensity if 9uN force acting on 3 μC charge.

DATA

q = 2μC

F = 9μN

E = ?

SOLUTION

E = $\frac{F}{q}$

E = $\frac{9}{3}$

F = 3 N/C

Worked Example 3 Calculate the p.d of 300mJ of work done on a 150 mC charge?

DATA

q = 150 mC

W = 300mJ

V = ?

SOLUTION

q = $\frac{W}{V}$

150 = $\frac{300}{V}$

V = $\frac{300}{150}$

V = 2 Volts

Worked Example 4 Calculate the coulombs force between two protons 10cm apart from each other? Charge on proton is 1.69 x 10^{-19} C and K =9.0 x 10^{9} N-m^2/C^2.

DATA

Charge of electron

e = 1.6 x 10^{-19}C

r = 10 cm = 0.1m

K = 9 x10^{9} Nm^2/C^2

F = ?

SOLUTION

F = $\frac{K\,q_1q_2}{r^2}$ **q=e**

F = $\frac{K\,e_1e_2}{r^2}$

F = $\frac{9\times10^{9}\times1.67\times10^{-19}\times1.67\times10^{-19}}{0.1^2}$

F = $\frac{23.04\times10^{-29}}{0.01}$

F = 2304 x 10^{-29}

Chapter 15

Numerical

1. When the current in a pocket calculator is 0.0002 A, how much charge flows every minute? (12mC)

DATA

I = 0.0002A

t = 1 min = 60 sec

q = ?

SOLUTION

I = $\frac{q}{t}$

0.0002 = $\frac{q}{60}$

q = 0.0002 x 60

q = 0.012 C

Or

q = 12mc

2. Calculate the amount of current that an electric heater uses to heat a room in 5 minutes if the charge is 2100 C. (7 A)

DATA

q = 2100 C

t = 5 min = 5 x 60 = 300 sec

I = ?

SOLUTION

I = $\frac{q}{t}$

I = $\frac{2100}{300}$

I = 7 Amp

3. A potential difference of 90 V exists between two points. The amount of work done when an unknown charge is moved between the points is 450J. Determine the charge amount (5 C)

DATA

V = 90 V

W = 450J

q = ?

SOLUTION

V = $\frac{w}{q}$

90 = $\frac{450}{q}$

q = $\frac{450}{90}$

q = 5C

4. Calculate the potential difference between two points A and B if it takes $9x10^4$J of external work to move a charge of +9 HC from A to B. (100 V)

DATA

W = 9×10^4J

q = 9HC = $9x10^2$ C

V = ?

SOLUTION

V = $\frac{w}{q}$

V = $\frac{9\times10^4}{9\times10^2}$

V = 10^2

V = 100 volts

5. The potential difference applied to a portable radio terminal is 6.0 Volts. Determine the resistance of the radio when a current of 20 mA flows through it. (300 Ω)

DATA

V = 6 volts

I = 20mA

R = ?

SOLUTION

V=IR

6 = 0.02 x R

$R = \frac{6}{0.02}$

R = 300 ohms

6. Resistances of 4 Ω, 6 Ω, and 12 Ω are connected in parallel and then connected to a 6V emf source. Determine the value of

1. The circuit's equivalent resistance. (2 2)
2. The total current flowing through the circuit. (3 A)
3. The current that flows through each resistance. (1.5 A, 1 A, 0.5 A)

DATA

R_1 = 4 Ω

R_2 = 6Ω

R_3 = 12Ω

V = 4 volts

R = ?

I = ?

I_1 = ?

I_2 = ?

I_3 = ?

SOLUTION

$$\frac{\mathbf{1}}{\boldsymbol{R}} = \frac{\mathbf{1}}{\boldsymbol{R_1}} + \frac{\mathbf{1}}{\boldsymbol{R_2}} + \frac{\mathbf{1}}{\boldsymbol{R_3}}$$

$$\frac{1}{R} = \frac{1^{\times 3}}{4} + \frac{1^{\times 2}}{6} + \frac{1^{\times 1}}{12}$$

$$\frac{1}{R} = \frac{3+2+1}{12}$$

$$\frac{1}{R} = \frac{6}{12}$$

$$R = \frac{12}{6}$$

R = 2 Ω

V= IR

6 = I x 2

$I = \frac{6}{2}$

I = 3 amp

When Resistance are in parallel

$V = V_1 = V_2 = V_3 = 6$volts

$\mathbf{I_1} = \frac{V_1}{R_1} = \frac{6}{4} = 1.5$ amp

$\mathbf{I_2} = \frac{V_2}{R_2} = \frac{6}{6} = 1$ amp

$\mathbf{I_3} = \frac{V_3}{R_3} = \frac{6}{12} = 0.5$ amp

7. A 220 V circuit is used to power two 120 watt and 80 watt light bulbs. Which bulb has the greater resistance and which one has the higher current? (80 W bulb, 120 W bulb)

DATA

V = 220 volts

$P_1 = 120$ watt

$P_1 = 80$ watt

which bulb have greater current

which bulb have greater resistance

SOLUTION

$\mathbf{P_1 = V_1 I_1}$

$120 = 220 \times I_1$

$I_1 = \frac{120}{220} = 0.5454$ amp

$\mathbf{P_2 = V_2 I_2}$

$80 = 220 \times I_2$

$I_2 = \frac{80}{220} = 0.3636$ amp

since $I_1 > I_2$, so bult 120 watt have greater current

$\mathbf{V_1 = I_1 R_1}$

$220 = 0.5454 \times R_1$

$R_1 = \frac{220}{0.5454} = 403.37\ \Omega$

$\mathbf{V_2 = I_2 R_2}$

$220 = 0.3636 \times R_2$

$R_2 = \frac{220}{0.3636} = 605.06\ \Omega$

since $R_2 > R_1$, so bult 80 watt have higher resistance

Worked Example 1 How much voltage will be dropped across a 50 kΩ resistance whose current is 300 μA?

DATA

R = 5KΩ = 5000 Ω

I = 300μA = 300 x 10^{-6} A

V = ?

SOLUTION

V = IR

V = 300 x10^{-6} x 5000

V = 15 x 10^{-6+5}

V = 15 x 10^{-1}

OR

V = 1.5 volts

Worked Example 2 Find the current passing through circuit and the voltage across each of the resistors. 100Ω, 400Ω and 200Ω Resistors in series with a 7volts battery.

DATA

R_1 = 100 Ω

R_2 = 400 Ω

R_3 = 200 Ω

V = 7 volts

R = ?

I = ?

V_1 = ?

V_2 = ?

V_3 = ?

SOLUTION

Resistance are connected in series

$R = R_1 + R_2 + R_3$

R = 100 + 400 + 200

R = 700 Ω

V = IR

7 = I x 700

$I = \frac{7}{700}$

I = 0.01amp

When resistance are in series

$I = I_1 = I_2 = I_3$ = 0.01 amp

$V_1 = I_1R_1$ = 0.01 x 100 = 1 volts

$V_2 = I_2R_2$ = 0.01 x 400 = 4 volts

$V_3 = I_3R_3$ = 0.01 x 200 = 2 volts

Worked Example 2 Find the current passing through circuit and the current across each of the resistors. 100Ω, 400Ω and 200Ω Resistors in parallel with a 7volts battery.

DATA

R_1 = 100 Ω

R_2 = 400 Ω

R_3 = 200 Ω

V = 7 volts

R = ?

I = ?

I_1 = ?

I_2 = ?

I_3 = ?

SOLUTION

Resistance in parallel, so

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R} = \frac{1^{\times 4}}{100} + \frac{1^{\times 1}}{400} + \frac{1^{\times 2}}{200}$$

$$\frac{1}{R} = \frac{4+1+2}{400}$$

$$\frac{1}{R} = \frac{7}{400}$$

$$R = \frac{400}{7}$$

R = 57.14 Ω

V= IR

7 = I x 2

$I = \frac{7}{57.14}$

I = 0.1225 amp

When Resistance are in parallel

$V = V_1 = V_2 = V_3$ = 7volts

$I_1 = \frac{V_1}{R_1} = \frac{7}{100}$ = 0.07 amp

$I_2 = \frac{V_2}{R_2} = \frac{7}{400}$ = 0.0175 amp

$I_3 = \frac{V_3}{R_3} = \frac{7}{200}$ = 0.035 amp

Worked Example 4 100J of heat is produced each second in a 4 Ω resistance, Find the potential difference across the resistor.

DATA

H = 100J

R = 4Ω

t = 1sec

V = ?

SOLUTION

$H = I^2Rt$

$100 = I^2 \times 4 \times 1$

$100 = 4I^2$

$I^2 = \frac{100}{4}$

$I^2 = 25$

$I = \sqrt{25}$

I = 5 amp

V =IR

V = 5 x 4

V = 20 volts

CHAPTER 16

Numerical

1. A wire carrying 4A current and has length of 15 cm between the poles of a magnet is kept at an angle of 30P to the uniform field of 0.8 T. Find the force acting on the wire? (0.24N)

DATA

I = 4amp

L = 15 cm = 15 ÷ 100 = 0.15m

B = 0.8 T

$\alpha = 30^o = Sin30^o = 0.5$

F = ?

SOLUTION

F = BIL sinα

F = 0.8 x 4 x 0.15 sin30

F = 48 x 0.5

F = 0.24 N

2. A square loop of wire of side 2.0 cm carries 2.0 A of current. A uniform magnetic field of magnitude 0.7 T makes an angle of 60° with the plane of the loop. What is the magnitude of torque on the loop? ($4.8x10^{-4}$ Nm)

DATA

I = 2amp

B = 0.7 T

$\alpha = 60^o = \cos 60^o = 0.5$

L = 2cm = 2 ÷ 100= 0.02

τ = IBA Cosα **since, A = l^2(for square)**

So, $\tau = IBL^2 Cos\alpha$

$\tau = 2 \times 0.7 \times 0.02^2 Cos60^o$

$\tau = 0.00056 \times 0.5$

$\tau = 0.00028$ N.m

OR

$\tau = 2.8 \times 10^{-4}$ N.m

3. A transformer is needed to convert a mains 220 V supply into a 12 V supply. If there are 2200 turns on the primary coil, then find the number of turns on the secondary coil. (120)

DATA

$V_1 = 220$ volts

$V_2 = 12$ volts

$N_1 = 220$ turns

$N_2 = ?$

SOLUTION

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\frac{220}{12} = \frac{2200}{N_2}$$

$220 \times N_2 = 2200 \times 12$

$N_2 = \frac{26400}{220}$

$N_2 = 120$ turns

4. A coil surrounding a long solenoid, the current in the solenoid is changing at a rate of 150A/s and the mutual induction of the two coils is 5.5×10^{-5}H. Determine the emf induced in the surrounding coil? -8.25×10^{-3}V).

DATA

$\frac{\Delta I}{\Delta t} = 150$ A/s

$M = 55 \times 10^{-5}$ H

$E = ?$

SOLUTION

$$M = -\frac{E}{\Delta I/\Delta t}$$

$$55 \times 10^{-5} = -\frac{E}{150}$$

$55 \times 10^{-5} \times 150 = -E$

$E = 0.00825$ volts

$E = 8.25 \times 10^{-3}$ volts

Numerical

1. A living plant contains approximately the same isotopic abundance of C-14 as does atmospheric carbon dioxide. The observed rate of decay of C-14 from a living plant is 15.3 disintegrations per minute per gram of carbon. How much disintegration per minute per gram of carbon will be measured from a 12900 year-old sample? (The half-life of C-14 is 5730 years.) (2.2513, 0.21, 3.2)

DATA

mass of sample = m = 1 gm

half life = $T_{1/2}$ = 5730 years

time =t = 12900 years old

SOLUTION

No of half life = n = $\frac{time}{half\ life} = \frac{12900}{5730}$

n = 2.251

mass remaining = $\frac{1}{2^n}$ x m

mass remaining = $\frac{1}{2^{2.251}}$ x 15.3

mass remaining = $\frac{1}{4.760}$ x 15.3

mass remaining = 0.21 x 15.3

mass remaining = 3.21 gm

2. The smallest C-14 activity that can be measured is about 0.20%. If C-14 is used to date an object, the object must have died within how many years? (51374 yr)

DATA

m = 0.20% = 0.0020

half life = $T_{1/2}$ = 5730 years

Time of death = ?

SOLUTION

n = $\frac{logm}{log0.5}$

n = $\frac{log0.002}{log0.5}$

n = 8.96

Time of death = n x half life

Time of death = 8.96 x 5730

Time of death = 51374 years

3. How long will it take for 25% of the C-14 atoms in a sample of C-14 to decay? (2378 yr)

DATA

m = 25% = 0.25

no of half life = t = ?

half life = $T_{1/2}$ =5730 years

SOLUTION

$$\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$$

$\Delta\% = \frac{N-N_o}{N_o}$

$-0.25 = \frac{N}{N_o} - \frac{N_o}{N_o}$

$-0.25 = \frac{N}{N_o} - 1$

$-0.25 + 1 = \frac{N}{N_o}$

$\frac{N}{N_o} = 0.75$

now, $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$

$$0.75 = (0.5)^{\frac{t}{T_{1/2}}}$$

taking log on both side

$\log 0.75 = \log(0.5)^{\frac{t}{5730}}$

$\log 0.75 = \frac{t}{5730} \log 0.5$

$\frac{log\ 0.75}{\log 0.5} = \frac{t}{5730}$

t = 0.415 x 5730

t = 23782.16 years

4. The carbon-14 decay rate of a sample obtained from a young tree is 0.296 disintegration per second per gram of the sample. Another wood sample prepared from an object recovered at an archaeological excavation gives a decay rate of 0.109 disintegration per second per gram of the sample. What is the age of the object? (8258 yr)

DATA

rate of sample of young tree = 0.296

rate of sample of recovered wood = 0.109

half life = $T_{1/2}$ =5730 years

Age of object = ?

SOLUTION

age of object = n x $T_{1/2}$

$\left(\frac{1}{2}\right)^n = \frac{rate\ recovered}{rate\ of\ current\ life}$

$\left(\frac{1}{2}\right)^n = \frac{0.109}{0.296}$

$\left(\frac{1}{2}\right)^n$ = 0.368

taking lof on both side

log 0.5^n =log0.368

n log 0.5 = log 0.368

n = $\frac{log 0.368}{log 0.5}$

n = 1.44

now ,

age of object = n x $T_{1/2}$

age of object = 1.44 x 5730

age of object = 8251 years

Worked Example 1 If there are 96 grams of radioactive element Neptunium-240 present, how much Np-240 will remain after 6 hours? (Neptunium-240 has a half-life of 1 hour)

DATA

mass of sample = m = 96 gm

half life = $T_{1/2}$ = 1hour

time =t = 6 hour

SOLUTION

No of half life = n = $\frac{time}{half\ life} = \frac{6}{1}$

n = 6

mass remaining = $\frac{1}{2^6}$ x 96

mass remaining = $\frac{1}{64}$ x 96

mass remaining = 1.5 gm

Worked Example 2 A sample of Ac-225 originally contained 8.0 x 10^{24} nuclei. After 960 hours, how much of the original sample remains un-decayed. The half-life of the isotope is ten days.

DATA

number of original nuclei = 8.0 x 10^{24}

time = t= 960 hours = $\frac{960}{24}$ = 40days

number of nuclei = ?

SOLUTION

n = $\frac{time}{half\ life}$ **=** $\frac{40}{10}$ = 4

number of nuclei = $\left(\frac{1}{2}\right)^n$ x number of original nuclei

number of nuclei = $\frac{1}{2^4}$ x 8.0 x 10^{24}

number of nuclei = $\frac{8.0\ x\ 10^{24}}{16}$

number of nuclei =0.5 x 10^{24}

Worked Example3 How long will it take to decay for 36.0 mg of Ra-226 to leave 4.5 mg? The half-life of the isotope is 1600 years.

DATA

mas of original sample = 36 mg

mass of remaining sample = 4.5 mg

half life = $T_{1/2}$ = 1600 years

total life = ?

SOLUTION

mass decay = $\left(\frac{1}{2}\right)^{n}$ **x mass**

4.5 = $\left(\frac{1}{2}\right)^{n}$ x 36

$\frac{4.5}{36} = \frac{1}{2^n}$

$2^n = \frac{36}{4.5}$

$2^n = 8$

$2^n = 2^3$

n = 3

n = $\frac{time}{half\ life}$

$3 = \frac{time}{1600}$

time = 3 x 1600

time = 4800 years