JEE Main Online Exam 2019

Questions & Solutions

9th April 2019 | Shift - I

PHYSICS

Q.1 An NPN transistor is used in common emitter configuration as an amplifier with 1 kΩ load resistance. Signal voltage of 10 mV is applied across the base-emitter. The produces a 3 mA change in the collector current and 15 μA change in the base current of the amplifier. The input resistance and voltage gain are –

(1) 0.67 kΩ, 300 (2) 0.67 kΩ, 200 (3) 0.33 kΩ, 1.5 (4) 0.33 kΩ, 300

Ans. **[1]**

Sol.

Current input = 15×10^{-6}

Current output = 3×10^{-3}

$R_0 = 1000$

$V_{in} = 10 \times 10^{-3}$

$V_{in} = r_{in} \times I_{in}$

$r_{in} = \frac{2000}{3} = .67\ k\Omega$

Voltage gain $= \frac{V_0}{V_i} = \frac{1000 \times 3 \times 10^{-3}}{10 \times 10^{-3}} = 300$

Q.2 For a given at 1 atm pressure, rms speed of the molecules is 200 m/s at 127ºC. At 2 atm pressure and at 227ºC, the rms speed of the molecules will be –

(1) 100m/s (2) $80\sqrt{5}$ m/s (3) $100\sqrt{5}$ m/s (4) 80 m/s

Ans. **[3]**

Sol. $V_{rms} = \sqrt{\frac{3RT}{M_W}}$

$\frac{V_2}{V_1} = \sqrt{\frac{T_2}{T_1}}$

$\frac{V_2}{200} = \sqrt{\frac{500}{400}}$

$V_2 = 100\sqrt{5}$

Q.3 A stationary horizontal disc is free to rotate about its axis. When a torque is applied on it, its kinetic energy as a function of θ, where θ is the angle by which is has rotated, is given as $k\theta^2$. If its moment of inertia is I then the angular acceleration of the disc is -

(1) $\frac{k}{I}\theta$ (2) $\frac{k}{2I}\theta$ (3) $\frac{k}{4I}\theta$ (4) $\frac{2k}{I}\theta$

Ans. **[4]**

Sol. Given that energy ⇒ $\frac{1}{2}I\omega^2 = k\theta^2$

$$\frac{1}{2}I\omega^2 = k\theta^2$$

By differentiate

$$\frac{1}{2}\ I \times 2\omega\ \frac{d\omega}{dt} = 2k\theta\ \frac{d\theta}{dt}$$

$$I\ \omega\ \frac{d\omega}{d\theta} = 2k\theta$$

$$\alpha = \frac{2k\theta}{I}$$

Q.4 The pressure wave, $P = 0.01 \sin [1000t - 3x]\ Nm^{-2}$, corresponds to the sound produced by vibrating blade on a day when atmospheric temperature is 0ºC. On some other day when temperature is T, the speed of sound produced by the same blade and at the same frequency is found to be 336 ms^{-1}/ Approximate value of T is -

(1) 4ºC (2) 12ºC (3) 11ºC (4) 15ºC

Ans. **[1]**

Sol. Speed of sound $= \frac{w}{k}$

$$= \frac{1000}{3}$$

$$v \propto \sqrt{T}$$

$$\frac{V_2}{V_1} = \sqrt{\frac{T_2}{T_1}}$$

$$\frac{336}{1000/3} = \sqrt{\frac{7}{273}}$$

T = 277 K (appr.)

T = 4ºC

Q.5 An HCl molecule has rotational, translational and vibrational motions. If the rms velocity of HCl molecules in its gaseous phase is $\bar{v}$, m is its mass and k_B is Boltzmann constant, then its temperature will be -

(1) $\frac{m\bar{v}^2}{7k_B}$ (2) $\frac{m\bar{v}^2}{6k_B}$ (3) $\frac{m\bar{v}^2}{5k_B}$ (4) $\frac{m\bar{v}^2}{3k_B}$

Ans. **[Bonus]**

Sol. Energy of molecules $= \frac{f}{2}\ kT$

For translational $\frac{1}{2}\ mV^2 = \frac{3}{2}kT$

$$T = \frac{mV^2}{3k}$$

According to Translational equation

Ans should be (4) $\frac{mV^2}{3K}$

NTA has given $\frac{mV^2}{6K}$ (2)

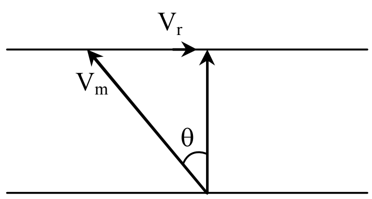
So NTA should correct this ans.

Q.6 The stream of a river is flowing with a speed of 2 km/h. A swimmer can swim at a speed of 4 km/h. What should be the direction of the swimmer with respect to the flow of the river to cross the river straight ?

(1) 60º (2) 90º (3) 150º (4) 120º

Ans. **[4]**

Sol.



$V_m \sin\theta = V_r$

$4 \sin\theta = 2$

$\sin\theta = \frac{1}{2}$

$\theta = 30^\circ$

Angle from river flow = 30º + 90º = 120º

Q.7 The following bodies are made to roll up (without slipping) the same inclined plane from a horizontal plane : (i) a ring of radius R, (ii) a solid cylinder of radius $\frac{R}{2}$ and (iii) a solid sphere of radius $\frac{R}{4}$. If, in each case, the speed of the center of mass at the bottom of the incline is same, the ratio of the maximum heights they climb is -

(1) 14 : 15 : 20 (2) 10 : 15 : 7 (3) 2 : 3 : 4 (4) 4 : 3 : 2

Ans. **[Bonus]**

Sol. By energy conservation

$$\frac{1}{2}mv^2\left(1+\frac{k^2}{r^2}\right) = mgh$$

$$h \propto \left(1+\frac{k^2}{r^2}\right)$$

$$h_1 : h_2 : h_3 \rightarrow (1+1) : \left(1+\frac{1}{2}\right) : \left(1+\frac{2}{5}\right)$$

$$\Rightarrow \quad 2 : \frac{3}{2} : \frac{7}{5}$$

$$\Rightarrow \quad 20 : 15 : 14$$

Ans. Should be 20 : 15 : 14

NTA has give 10 : 15 : 7

So (Q) should bonus by NTA

Q.8 The magnetic field of a plane electromagnetic wave is given by :

$\vec{B} = B_0\,\hat{i}\,[\cos(kz - \omega t)] + B_1\,\hat{j}\,\cos(kz + \omega t)$

Where $B_0 = 3 \times 10^{-5}$ T and $B_1 = 2 \times 10^{-6}$T. The rms value of the force experienced by a stationary charge Q = 10^{-4} C at z = 0 is closest to -

(1) 0.6 N (2) 3×10^{-2} N (3) 0.9 N (4) 0. 1N

Ans. **[1]**

Sol. Maximum Electric Field = BC

$F_{net} = q\,\vec{E}_{net}$

$= qC(-3 \times 10^{-5}\,\hat{j} - 2 \times 10^{-6}\,\hat{i})$

$= 10^{-4} \times 3 \times 10^{8}\sqrt{(3\times10^{-5})^2 + (2\times10^{-6})^2}$

$= .9$ N

$F_{rms} = \frac{F_0}{\sqrt{2}} = .6$ N

Q.9 A solid sphere of mass 'M' and radius 'a' is surrounded by a uniform concentric spherical shell of thickness 2a and mass 2M. The gravitational field at distance '3a' from the centre will be -

(1) $\frac{GM}{9a^2}$ (2) $\frac{2GM}{9a^2}$ (3) $\frac{2GM}{3a^2}$ (4) $\frac{GM}{3a^2}$

Ans. **[4]**

Sol. According to gauss theorem

$g4\pi\,(3a)^2 = 3M\,4\pi G$

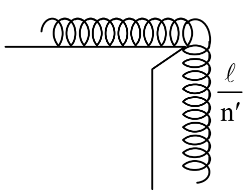
$g = \frac{GM}{3a^2}$

Q.10 A uniform cable of mass 'M' and length 'L' is placed on a horizontal surface such that its $\left(\frac{1}{n}\right)^{th}$ part is hanging below the edge of the surface. To lift the hanging part of the cable upto the surface, the work done should be -

(1) nMgL (2) $\frac{MgL}{2n^2}$ (3) $\frac{2MgL}{n^2}$ (4) $\frac{MgL}{n^2}$

Ans. **[2]**

Sol.



Work done against gravity

$= mgh$

$= \frac{m}{n}\,g\,\frac{\ell}{2n}$

$= \frac{mg\ell}{2n^2}$

Q.11 A rectangular coil (Dimension 5 cm × 2.5 cm) with 100 turns, carrying a current of 3 A in the clock-wise direction, is kept centered at the origin and in the X-Z plane. A magnetic field of 1 T is applied along X-axis. If the coil is tilted through 45º about Z-axis, then the torque on the coil is -

(1) 0.55 Nm (2) 0.38Nm (3) 0.42 Nm (4) 0.27 Nm

Ans. **[4]**

Sol. $\iota = M \times B$

$= NIA\ B \sin\theta$

$= 100 \times 3 \times 5 \times 2.5 \times 10^{-4} \times 1 \times \sin 45^\circ$

$= .27$ Nm

Q.12 The electric field of light wave is given as $\vec{E} = 10^{-3} \cos\left(\frac{2\pi x}{5\times10^{-7}} - 2\pi\times6\times10^{14}t\right)\hat{x}\ \frac{N}{C}$. This light falls on a metal plate of work function 2eV. The stopping potential of the photo-electrons is : Given, E (in eV) = $\frac{12375}{\lambda(\text{in Å})}$.

(1) 0.72 V (2) 2.0 V (3) 0.48 V (4) 2.48 V

Ans. **[3]**

Sol. $\omega = 2\pi n = 2\pi \times 6\ 10^{14}$

$n = 6 \times 10^{14}$

$V = n\lambda$

$\lambda = \frac{3\times10^8}{6\times10^{14}} = 5000$

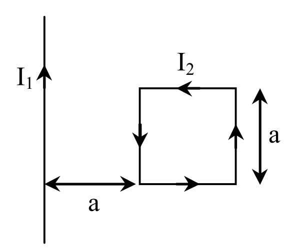
$E_n = \frac{12375}{5000} = 2.475$

$KE_{rmx} = E - \phi$

$eV_s = (2.475 - 2)$ eV

$V_s = .475\ V = .48\ V$

Q.13 A rigid square loop of side 'a' and carrying current I_2 is lying on a horizontal surface near a long current I_1 carrying wire in the same plane as shown in figure. The net force on the loop due to the wire will be –



(1) zero

(2) Repulsive and equal to $\frac{\mu_0 I_1 I_2}{4\pi}$

(3) Repulsive and equal to $\frac{\mu_0 I_1 I_2}{2\pi}$

(4) Attractive and equal to $\frac{\mu_0 I_1 I_2}{3\pi}$

Ans. **[2]**

Sol. Force of PQ

$F_1 = I_2 B_1 A$

$= I_2 \frac{\mu_0 I_1}{2\pi a} a$

Force of RS

$F_2 = I_2B_2a$

$= I_2 \dfrac{\mu_0 I_1}{2\pi(2a)} a$

Net force $F_1 - F_2$

$= \dfrac{\mu_0 I_1 I_2}{4\pi}$ (Repulsive)

Q.14 In the density measurement of a cube, the mass and edge length are measured as (10.00 ± 0.10) kg and (0.10 ± 0.01) m, respectively. The error in the measurement of density is -

(1) 0.31 kg/m^3 (2) 0.10 kg/m^3 (3) 0.01 kg/m^3 (4) 0.07 kg/m^3

Ans. **[Bonus]**

Sol. $M = 10 \pm .10$

$\ell = .10 \pm .01$

$\rho = \dfrac{M}{\ell^3} = \dfrac{10}{(.1)^3} = 10^4$

$\dfrac{\Delta\rho}{\rho} = \dfrac{\Delta M}{M} + \dfrac{3\Delta\ell}{\ell}$

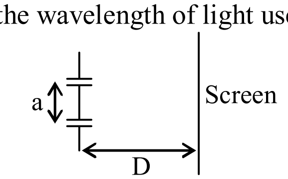
$= \dfrac{.10}{10} + \dfrac{3\times.01}{.10}$

$= \dfrac{1}{100} + \dfrac{3}{10}$

$\dfrac{\Delta\rho}{\rho} = \dfrac{31}{100}$

$\dfrac{\Delta\rho}{\rho} = .31$ This Ans. is not for error in density it is relative error. So (Q) should be Bonus.

Q.15 The figure shows a Young's double slit experimental setup. It is observed that when a thin transparent sheet of thickness t and refractive index μ is put in front of one of the slits, the central maximum gets shifted by a distance equal to n fringe widths. If the wavelength of light used is λ, t will be :



(1) $\dfrac{2nD\lambda}{a(\mu-1)}$ (2) $\dfrac{nD\lambda}{a(\mu-1)}$ (3) $\dfrac{D\lambda}{a(\mu-1)}$ (4) $\dfrac{2D\lambda}{a(\mu-1)}$

Ans. **[Bonus]**

Sol. Path difference $\Delta = (\mu - 1)t$

$(\mu - 1)t\dfrac{D}{d} = \dfrac{n\lambda D}{d}$

$f = \dfrac{n\lambda}{\mu-1}$

correct ans. Should be $\dfrac{n\lambda}{\mu-1}$

NTA has given $\dfrac{nD\lambda}{a(\mu-1)}$, So it should be bonus

Q.16 A moving coil galvanometer has resistance 50Ω and it indicates full deflection at 4mA current. A voltmeter is made using this galvanometer and a 5kΩ resistance. The maximum voltage, that can be measured using this voltmeter, will be close to :

(1) 40 V (2) 10 V (3) 15 V (4) 20 V

Ans. **[4]**

Sol. $V = I_g (G + S)$

$V = 4 \times 10^{-3} (50 + 5000)$

$= 4 \times 10^{-3} \times 5050$

$= 20$ V (approximate)

Q.17 Taking the wavelength of first Balmer line in hydrogen spectrum (n = 3 to n = 2) as 660 nm, the wavelength of the 2nd Balmer line (n = 4 to n = 2) will be :

(1) 889.2 nm (2) 388.9 nm (3) 488.9 nm (4) 642.7 nm

Ans. **[3]**

Sol. $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

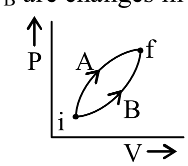
$\frac{1}{660} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$

$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16}$

$\frac{\lambda}{660} = \frac{5/36}{3/11}$

$\lambda = 488.88$

Q.18 Following figure shows two processes A and B for a gas. If ΔQ_A and ΔQ_B are the amount of heat absorbed by the system in two cases, and ΔU_A and ΔU_B are changes in internal energies, respectively, then :

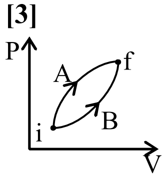


(1) $\Delta Q_A > \Delta Q_B$, $\Delta U_A > \Delta U_B$ (2) $\Delta Q_A < \Delta Q_B$, $\Delta U_A < \Delta U_B$

(3) $\Delta Q_A > \Delta Q_B$, $\Delta U_A = \Delta U_B$ (4) $\Delta Q_A = \Delta Q_B$; $\Delta U_A = \Delta U_B$

Ans. **[3]**

Sol.



Initial & final point are same

So, $dU_A = dU_B$

$dW_A > dW_B$ (Area)

So, $dQ_A > dQ_B$ $(dQ = dU + dW)$

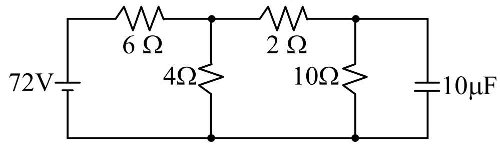
Q.19 If 'M' is the mass of water that rises in a capillary tube of radius 'r', then mass of water which will rise in a capillary tube of radius '2r' is :

(1) M (2) 4 M (3) $\frac{M}{2}$ (4) 2 M

Ans. **[1]**

Sol. Light will change with change in radius mass remain same

Q.20 Determine the charge on the capacitor in the following circuit :

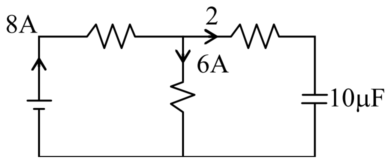


(1) 200 μC (2) 10 μC (3) 60 μC (4) 2 μC

Ans. **[1]**

Sol. Total Resistance = 9

Total current 8 cm



Voltage at 10Ω = 20V

q = CV

= 10 μF × 20 = 200 μC

Q.21 The total number of turns and cross-section area in a solenoid is fixed. However, its length L is varied by adjusting the separation between windings. The inductance of solenoid will be proportional to :

(1) L (2) L^2 (3) $1/L^2$ (4) 1/L

Ans. **[4]**

Sol. $\phi = NBA = LI$

$N\mu_0 nI\pi r^2 = LI$

$N\mu_0 \frac{N}{\ell} \pi r^2 I = LI$

$L \propto \frac{1}{\ell}$

Q.22 A concave mirror for face viewing has focal length of 0.4 m. The distance at which you hold the mirror from your face in order to see your image upright with a magnification of 5 is :

(1) 1.60 m (2) 0.16 m (3) 0.32 m (4) 0.24 m

Ans. **[3]**

Sol. $m = \frac{f}{f-u} = \frac{-40}{-40-u}$

u = – 32 cm

Q.23 A capacitor with capacitance 5 μF is charged to 5μC. If the plates are pulled apart to reduce the capacitance to 2μF, how much work is done?

(1) 3.75×10^{-6} J (2) 6.25×10^{-6} J (3) 2.55×10^{-6} J (4) 2.16×10^{-6} J

Ans. **[1]**

Sol. Work = $U_f - U_i$

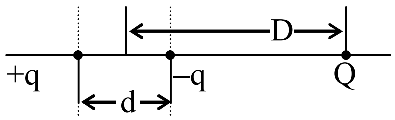
$= \frac{q^2}{2C_2} - \frac{q^2}{2C_1}$

$= \frac{(5\times10^{-6})^2}{2}\left(\frac{1}{2\times10^{-6}} - \frac{1}{5\times10^{-6}}\right)$

$= \frac{15}{4} \times 10^{-6}$

$= 3.75 \times 10^{-6}$

Q.24 A system of three charges are placed as shown in the figure :

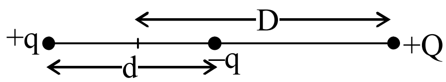


If D >> d, the potential energy of the system is best given by :

(1) $\frac{1}{4\pi\in_0}\left[+\frac{q^2}{d}+\frac{qQd}{D^2}\right]$ (2) $\frac{1}{4\pi\in_0}\left[-\frac{q^2}{d}-\frac{qQd}{D^2}\right]$ (3) $\frac{1}{4\pi\in_0}\left[-\frac{q^2}{d}+\frac{2qQd}{D^2}\right]$ (4) $\frac{1}{4\pi\in_0}\left[-\frac{q^2}{d}-\frac{qQd}{2D^2}\right]$

Ans. **[2]**

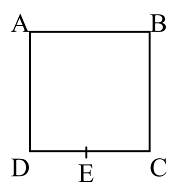
Sol.



$$u = -\frac{kq^2}{d} - \frac{kQ(qd)}{D^2}$$

$$= -k\left[\frac{q^2}{d} + \frac{qQd}{D^2}\right)$$

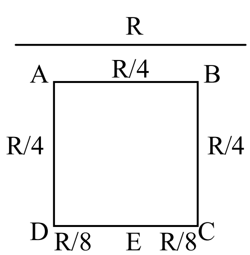
Q.25 A wire of resistance R is bent to form a square ABCD as shown in the figure. The effective resistance between E and C is : (E is mid-point of arm CD)



(1) $\frac{3}{4}$R (2) $\frac{1}{16}$R (3) $\frac{7}{64}$R (4) R

Ans. **[3]**

Sol.



$$R_{EDABC} = \frac{R}{4} + \frac{R}{4} + \frac{R}{4} + \frac{R}{8} = \frac{7R}{8}$$

$$R_{EC} = \frac{R}{8}$$

$$\text{Effective resistance} = \frac{\frac{R}{8}\times\frac{7R}{8}}{\frac{R}{8}+\frac{7R}{8}} = \frac{7R}{64}$$

Q.26 A simple pendulum oscillating in air has period T. The bob of the pendulum is completely immersed in a non-viscous liquid. The density of the liquid is $\frac{1}{16}$ th of the material of the bob. If the bob is inside liquid all the time, its period of oscillation in this liquid is :

(1) $2T\sqrt{\frac{1}{14}}$ (2) $2T\sqrt{\frac{1}{10}}$ (3) $4T\sqrt{\frac{1}{15}}$ (4) $4T\sqrt{\frac{1}{14}}$

Ans. [3]

Sol. $T = 2\pi\sqrt{\frac{\ell}{g}}$

When immersed in liquid

Tension $\Rightarrow T' = mg - m'g$

$T' = mg\left(1 - \frac{m'}{m}\right)$

$T' = T\left(1 - \frac{Vd\ell}{Vd_0}\right)$

$T' = T\left(1 - \frac{1}{16}\right)$

$T' = \frac{15T}{16}$

$g' = \frac{15}{16}g$

$\frac{T'}{T} = \sqrt{\frac{16}{15}}$

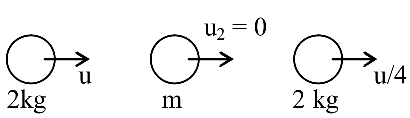
$T' = \frac{4T}{\sqrt{5}}$

Q.27 A body of mass 2kg makes an elastic collision with a second body at rest and continues to move in the original direction but with one fourth of its original speed. What is the mass of the second body?

(1) 1.5 kg (2) 1.2 kg (3) 1.0 kg (4) 1.8 kg

Ans. [2]

Sol.



$V_1 = \frac{2m_2u_2 + u_1(m_1 - m_2)}{m_1 + m_2}$

$\frac{u}{4} = \frac{O + u(2 - m)}{2 + m}$

$2 + m = 8 - 4m$

$5m = 6$

$m = 1.2$ kg

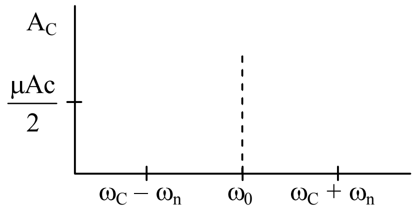
Q.28 A signal $A\cos\omega t$ is transmitted using $\nu_0 \sin\omega_0 t$ as carrier wave. The correct amplitude modulated (AM) signal is :

1. $\nu_0 \sin[\omega_0(1 + 0.01\, A\sin\omega t)t]$
2. $\nu_0 \sin\omega_0 t + A\cos\omega t$
3. $\nu_0 \sin\omega_0 t + \frac{A}{2}\sin(\omega_0 - \omega)t + \frac{A}{2}\sin(\omega_0 + \omega)t$
4. $(\nu_0 + A)\cos\omega t \sin\omega_0 t$

Ans. **[3]**

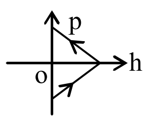
Sol. According to standard result is should be

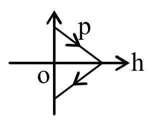
$$= A_C \sin\omega_C t + \frac{\mu A_C}{2}\sin(\omega_0 - \omega)t + \frac{\mu A}{2}\sin(\omega_0 + \omega)t$$

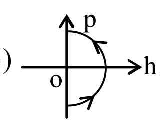


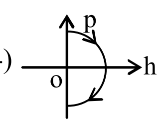
So, Ans. [3]

Q.29 A ball is thrown vertically up (taken as + z-axis) from the ground. The correct momentum-height (p-h) diagram is :

(1) 

(2) 

(3) 

(4) 

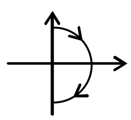
Ans. **[4]**

Sol. When thrown upward, (h = 0) $V \to$ max

$V^2 = u^2 + 2as$

$V^2 = u^2 - 2gh$ (Parabola)

When downward ($h \to$ max, $V \to 0$)



Q.30 A string is clamped at both the ends and it is vibrating in its 4^{th} harmonic. The equation of the stationary wave is $Y = 0.3 \sin(0.157x) \cos(200\pi t)$. The length of the string is : (All quantities are in SI units.)

(1) 40 m (2) 80 m (3) 20 m (4) 60 m

Ans. **[2]**

Sol. $y = a\sin(.157x)\cos(200\pi t)$

$$\frac{2\pi}{\lambda} = .157$$

$\lambda = 40$

4^{th} harmonic real

$$\ell = 4\frac{\lambda}{2}$$

$\ell = 2\lambda$

$= 80$ m