29.47. we know that -

$\frac{N_s}{N_p} = \frac{V_s}{V_p}$ (N_s, N_p denote no. of coils in secondary, primary coil
V_s, V_p " voltage " " " ")

$= \frac{12\,000}{240} = 50$

On ~~reversing~~ connecting backward, the primary and secondary coils are exchanged i.e.

$\frac{N_s}{N_p} = \frac{1}{50} = \frac{V_s}{240}$ $\therefore$ $V_s = \frac{240V}{50} = 4.8V$

29.67. $I = \frac{E}{R}$

$$E = -N_{coil} \frac{d\phi}{dt}$$

The magnetic field inside a solenoid $B = \mu_0 \frac{I_{sol} N}{l}$

$\phi = B \times$ Area

$$\frac{d\phi}{dt} = A \times \frac{d}{dt}\left(\frac{\mu_0 I_{sol} N}{l}\right) = \frac{\mu_0 I A N}{l} \frac{dI_{sol.}}{dt}$$

$$I = N_{coil} \frac{\mu_0 I A N}{l R} \frac{dI_{sol.}}{dt}$$

$$= \frac{(150 \text{ turns}) \pi (0.045 \text{ m})^2 (4\pi \times 10^{-7} \text{ T m/A}) (230 \text{ turns})}{12 \Omega \times 0.01 \text{ m}} \times \frac{2 \text{ A}}{0.1 \text{ s}}$$

$$= 4.6 \times 10^{-2} \text{ A}$$

On increasing current in solenoid, the magnetic increases from right to left. The induced current must flow from left to right across the resistor to create an opposing magnetic field.

29.68. The emf produced is the average emf over a whole cycle during which the coil changes its orientation and so also the flux.

$$E_{avg.} = -N \frac{\Delta \phi_B}{\Delta t} = -NA \frac{\Delta B}{\Delta t} = -NA \frac{(\overbrace{(-B) - (+B)}^{\text{due to change by rotation magnetic field changes from } -B \text{ to } +B.})}{\Delta t}$$

$$= \frac{2NAB}{\Delta t}$$

$$Q = I \Delta t = I \times \frac{2NAB}{E_{avg.}} = \frac{E_{avg.}}{R} \times \frac{2NAB}{E_{avg.}}$$

$\left(\because I = \frac{E_{avg.}}{R}\right)$

$$\therefore Q = \frac{2NAB}{R} \Rightarrow B = \frac{QR}{2NA}$$

30.1. a) The mutual inductance is given by -

$$M = \frac{\mu N_1 N_2 A}{l} = \frac{1850 (4\pi \times 10^{-7} \text{ Tm/A})(225)(115)\pi (0.02\text{ m})^2}{2.44 \text{ m}}$$

$$= 3.1 \times 10^{-2} \text{ H}$$

b) The emf induced in the coil is -

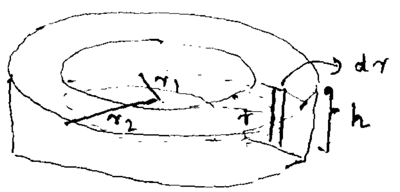
$$E = -M \frac{dI_1}{dt} = -3.1 \times 10^{-2} \times \frac{(-12 \text{ A})}{0.098 \text{ ms}} = 3.79 \text{ V}$$

30.6. The inductance of a solenoid is given by -

$$L = \frac{\mu_0 N^2 A}{l}$$

$$N = \sqrt{\frac{L l}{\mu_0 A}} = \sqrt{\frac{(0.13\,H)(0.3\,m)}{(4\pi \times 10^{-7}\,Tm/A)\,\pi\,(0.021\,m)^2}} \approx 4700 \text{ turns}$$

30.13. $L = \frac{N}{I}\Phi_B$



The flux across the whole needs to be calculated using the magnetic field inside it as -

$$B(r) = \frac{\mu_0 N I}{2\pi r}$$

$$L = \frac{N}{I}\int_{r_1}^{r_2} \frac{\mu_0 N I}{2\pi r} \underbrace{h\,dr}_{\text{Area}} = \frac{\mu_0 N^2 h}{2\pi}\int_{r_1}^{r_2}\frac{dr}{r}$$

$$= \frac{\mu_0 N^2 h}{2\pi}\ln\left(\frac{r_2}{r_1}\right)$$

30.15. The magnetic field energy density is given by -

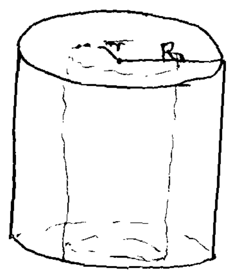
$$u = \frac{\text{Energy stored}}{\text{Volume}} = \frac{1}{2}\frac{B^2}{\mu_0}$$

$$\text{Energy stored} = \frac{1}{2}\frac{B^2}{\mu_0} \times \text{Volume} = \frac{1}{2}\frac{B^2}{\mu_0}\underbrace{\pi r^2 l}_{\text{Volume of cylinder}}$$

$$= \frac{1}{2}\frac{(0.6\,T)^2}{(4\pi\times10^{-7}\,Tm/A)}\,\pi\,(0.0105\,m)^2(0.380\,m)$$

$$= 18.9\,J$$

30.21.



we find the magnetic field inside using Ampere's law -

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{encl.}$$

$$B \times 2\pi r = \mu_0 I \times \frac{\pi r^2}{\pi R^2}$$

$$B = \frac{\mu_0 I r}{2\pi R^2}$$

$$\text{Energy density per unit length} = \frac{U}{l} = \frac{1}{l}\int u_B\,dV = \int \frac{B^2}{2\mu_0}\times \underbrace{2\pi r\,dr}_{dV}$$

$$= \int \frac{\mu_0^2 I^2 r^2}{4\pi^2 R^4}\times\frac{1}{2\mu_0}\,2\pi r\,dr = \frac{\mu_0 I^2}{4\pi R^4}\int_0^R r^3\,dr$$

$$= \frac{\mu_0 I^2}{4\pi R^4}\times\frac{R^4}{4} = \frac{\mu_0 I^2}{16\pi}$$

31.3. The current in the wire arises due to displacement current which is given by -

$$I_D = \varepsilon_0 A \frac{dE}{dt}$$

$$\frac{dE}{dt} = \frac{I_D}{\varepsilon_0 A} = \frac{2.8A}{(8.85\times10^{-12}\,C^2/Nm^2)\,(0.016\,m)^2} = 1.2\times10^{15}\ \frac{V}{m\,s}$$

meter second
not mili second

31.9. The electric and magnetic field are related by -

$$\frac{E_0}{B_0} = c \quad \therefore\ E_0 = B_0\,c = (12.5\times10^{-9}\,T)\,(3\times10^8\,m/s) = 3.75\,V/m$$

31.11. a) For the term with cos function, $KZ + \omega t = K(Z + ct)$
This shows that the wave is travelling along negative Z direction with speed c.

b) The direction of wave propogation is given by $\vec{E}\times\vec{B}$. Since $\vec{E}$ is along x axis, for $\vec{E}\times\vec{B}$ to be along negative Z axis, $\vec{B}$ must be along negative Y axis. $B_0 = E_0/c$ (relating magnitude of $\vec{B}$ with $\vec{E}$)

$$\therefore \vec{B} = -\frac{E_0}{c}\cos(KZ + \omega t)\,\hat{j}$$

31.14. a) $c = \lambda f \qquad \lambda = \frac{c}{f} = \frac{3\times10^8\,m/s}{25.75\times10^9\,Hz} = 1.165\times10^{-2}\,m$

b) $f = \frac{c}{\lambda} = \frac{3\times10^8\,m/s}{0.12\times10^{-19}\,m} = 2.5\times10^{18}\,Hz$

31.15. $d = vt$, d - distance, v - speed of wave, t - time taken

$$t = \frac{d}{v} = \frac{(1.5\times10^{11}\,m)}{3\times10^8\,m/s} = 5\times10^2\,s = 8.33\ min$$

31.20. a) A wave eq. can be written as $E = E_0\sin(KZ - \omega t)$

$$\lambda = \frac{2\pi}{K} = \frac{2\pi}{0.077\,m^{-1}} = 81.60\,m$$

$$f = \frac{\omega}{2\pi} = \frac{2.3\times10^7\,rad/s}{2\pi} = 3.661\times10^6\,Hz$$

b) The magnitude of the magnetic field would be $B_0 = \frac{E_0}{c}$
The wave travels along positive Z axis. Since $\vec{E}$ is along positive X axis, $\vec{B}$ must be along positive Y axis to have $\vec{E}\times\vec{B}$ along Z axis.

$$B_0 = \frac{E_0}{c} = \frac{225\,V/m}{3\times10^8\,m/s} = 7.5\times10^{-7}\,T$$

$$\vec{B} = (7.5\times10^{-7}\,T)\,\sin\left((0.077\,m^{-1})Z - (2.3\times10^7\,rad/s)t\right)\,\hat{j}$$

31.25. The intensity of a wave is the power emitted per unit area.

$\bar{S} = \frac{P}{A}$ A denotes area of a sphere as energy is emitted in all directio

$= \frac{1500\,W}{4\pi(5m)^2} = 4.775\ W/m^2$

$\bar{S} = c\,\varepsilon_0\,E_{rms}^2$

$E_{rms} = \sqrt{\frac{\bar{S}}{c\,\varepsilon_0}} = \sqrt{\frac{4.775\,W/m^2}{(3\times10^8 m/s)(8.85\times10^{-12}\,c^2/N\,m^2)}} = 42\,V/m$

31.28. Using above relations,

$S = \frac{P}{A} = c\,\varepsilon_0\,E^2_{rms}$

$E_{rms} = \sqrt{\frac{P}{A\,\varepsilon_0\,c}} = \sqrt{\frac{0.0158W}{\pi(1\times10^{-3}m)^2(3\times10^8 m/s)(8.85\times10^{-12}c^2/Nm^2)}}$

$= 1376.3\ V/m$

$B_{rms} = \frac{E_{rms}}{c} = \frac{1376.3\ V/m}{3\times10^8\ m/s} = 4.59\times10^{-6}\ T$

31.31. Since a solar polar can convert 10 % of the sun's energy, intensity being put to use is $\frac{10}{100}\times 1000\ W/m^2 = 100\ W/m^2$

a) $A = \frac{P}{I} = \frac{50\times10^{-3}W}{100\ W/m^2} = 5\times10^{-4}\ m^2 = 5\ cm^2$

A calculator can be estimated to dimensions like 17 cm × 8 cm. So ~~its~~ given its area, ~~it~~ the solar panel can be mounted on it.

b) $A = \frac{P}{I} = \frac{1500W}{100W/m^2} = 15m^2$

A ~~A~~ roof top of a house would be about $100m^2$. Hence a solar panel on it can supply enough energy for a hair dryer.

c) $A = \frac{P}{I} = \frac{20hp(746\ w/hp)}{100\ w/m^2} = 149\,m^2$

A car's roof top cannot be so big that it can support such a big solar panel. Hence it is not possible.

31.35. The radiation pressure of the laser exerts a force on the cylinder and makes it accelerate. The rate of energy supply is $\frac{dU}{dt} = 1W = P$

$\bar{S} = \frac{Power}{A}$

The radiation pressure is given as -

$\vec{P} = \frac{\bar{S}}{c}$ and the force exerted on the object due to this pressure is -

$F = PA = \frac{\bar{S}}{c} A = \frac{1}{c}\frac{dU}{dt} = ma$, a denotes acceleration.

$m = \rho_{H_2O} \pi r^2 (r)$

$\therefore\ a = \frac{\frac{dU}{dt}}{c\rho_{H_2O}\pi r^3} = \frac{1\,W}{(3\times10^8 m/s)(1000 kg/m^3)\pi(5\times10^{-7}m)^3}$

$= 8\times10^6\ m/s^2$

31.38. a) For FM radio,

$\lambda_{min.} = \frac{c}{f_{max}} = \frac{3\times10^8 m/s}{1.08\times10^8 Hz} = 2.78m$

$\lambda_{max.} = \frac{c}{f_{min}} = \frac{3\times10^8 m/s}{8.8\times10^7 Hz} = 3.41m$

b) For AM waves,

$\lambda_{min.} = \frac{c}{f_{max}} = \frac{3\times10^8 m/s}{1.7\times10^6 Hz} = 180\,m$

$\lambda_{max} = \frac{c}{f_{min.}} = \frac{3\times10^8 m/s}{5.35\times10^5 Hz} = 561m$

31.39. $\lambda = \frac{c}{f} = \frac{3\times10^8 m/s}{1.9\times10^9 Hz} = 0.16\,m$

31.42. $S = \frac{P}{A} = c\varepsilon_0 E_{rms}^2$ The radius turnsout to be $\frac{1500m}{2} = 750\,m$

$E_{rms} = \sqrt{\frac{P}{Ac\varepsilon_0}}$

$= \sqrt{\frac{1.2\times10^4 W}{\pi(750m)^2(3\times10^8 m/s)(8.85\times10^{-12} c^2/Nm^2)}} = 1.6V/m$

31.54. $\bar{S} = \frac{1}{2}\varepsilon_0 c E_0^2$ (average intensity)

$= \frac{P}{A} = \frac{P}{4\pi r^2}$

The wave emits energy in all directions, the house appears to be a point on this energy sphere spread around.

$\therefore\ r = \sqrt{\frac{2P}{4\pi\varepsilon_0 c E_0^2}} = \sqrt{\frac{25000W}{2\pi(8.85\times10^{-12}c^2/Nm^2)(3\times10^8 m/s)(0.02V/m)^2}}$

$= 61,200\,m \simeq 61\,Km$