



2)

$$a) r_{max} = 4 \sqrt{\frac{P_r \cdot G_r \cdot G_n \cdot \sigma \cdot \lambda^2}{(4\pi)^3 \cdot P_{min} \cdot L_{ges}}}$$

$$= 4 \sqrt{\frac{30 \times 10^3 \cdot 30 \cdot 30 \cdot 200 \cdot 0.03^2}{(4\pi)^3 \cdot 1 \times 10^{-8} \cdot 0.9}}$$

$$= 406.15 \text{ m}$$

722.26 m to 2d.p

$$P_r = 30 \text{ kW}$$

$$G_r = G_n = 30 \text{ dB}$$

$$f = 10 \text{ GHz}$$

$$\lambda = \frac{c}{f}$$

$$= \frac{3 \times 10^8}{10 \times 10^9}$$

$$= 0.03 \text{ m}$$

$$\sigma = 200 \text{ m}^2$$

$$P = 90 \text{ dBW} + 10 \text{ dB}$$

$$= -80$$

$$10^{(-80/10)} = 1 \times 10^{-8}$$

$$= P_{min}$$

$$L_{ges} = 0.9$$

$$\frac{49}{80}$$

b) X-Band radar is particularly good at target discrimination due to its relatively low power when compared to L-Band. It is therefore particularly good for small maritime use.

Nothing here of value

$$\frac{0}{6}$$

$$\frac{48}{100}$$

$$4 \sqrt{2.721223218 \times 10^{11}} =$$

$$\frac{4860000}{1.785961537 \times 10^{-5}}$$

3)

$$a) \text{ Power Flow} = \frac{1}{2} |E| |H|$$

$$\therefore 1 \text{ W/m}^2 = \frac{1}{2} |E| |H|$$

$$= \frac{1}{2} E \cdot E$$

$$377$$

$$= \frac{E^2}{377 \cdot 754}$$

$$\therefore E^2 = \frac{1}{754}$$

$$E = \sqrt{\frac{1}{754}}$$

$$= 0.04 \text{ V/m to 2 d.p.}$$

$$E^2 = 1 \times 754$$

$$= 754$$

$$E = \sqrt{754}$$

$$= 27.46 \text{ V/m to 2 d.p.}$$

$$b) \text{ Power Density} = \text{Field Strength} \times \text{Time}$$

$$= 10^7 \times 2 \mu\text{s}$$

$$= 10^7 \times 2 \times 10^{-6}$$

$$= 2 \times 10^4 \text{ W}$$

$$\text{Pulse Energy} = \text{Power Density} \times \text{Area}$$

$$= 2 \times 10^4 \times \left(\frac{\pi d^2}{4} \right)$$

$$= 2 \times 10^4 \times \left(\frac{\pi \cdot 11 \mu\text{m}^2}{4} \right)$$

$$= 2 \times 10^4 \times \left(\frac{\pi \cdot (11 \times 10^{-6})^2}{4} \right)$$

$$= 1.9 \text{ J}$$

little idea of (b).

4) Given $V_g = V_p \left(1 + \frac{\lambda}{n} \cdot \frac{dn}{d\lambda} \right)$

a)

and b) $n = 1.51$ at 400 nm

$n = 1.49$ at 600 nm

$$V_p = \frac{c}{n}$$

$$V_p = \frac{3 \times 10^8}{n}$$

$$\text{Average } n = \frac{1.51 + 1.49}{2}$$

$$= 1.50$$

$$= \frac{3 \times 10^8}{1.50}$$

$$\textcircled{b} = 2 \times 10^8 \text{ m/s}$$

Difference in $n = 1.51 - 1.49$

$$= 0.02$$

$$\text{Average } \lambda = \frac{400 + 600}{2}$$

$$= 500$$

Difference in $\lambda = 400 - 600$

$$= -200$$

$$\therefore V_g = 2 \times 10^8 \left(1 + \frac{500}{1.50} \cdot \frac{0.02}{-200} \right)$$

$$= 1.93 \times 10^8 \text{ m/s to 2 d.p. } \textcircled{a}$$

c) Mathematically Group Velocity can result in a speed that is greater than the speed of light. However, Phase Velocity should be used to determine the speed at which the information would travel.

(b) $\neq V_{\text{rel}} \neq V_{\text{phase}}$ not calculated.

$$\frac{30}{50}$$

$$\frac{15}{20}$$

$$\frac{45}{100}$$