1. $\lambda = 2.7\times10^{-11}$ m $c = f\lambda$

$\therefore f = c/\lambda = \frac{3.00\times10^{8}}{2.7\times10^{-11}}$

$\therefore f = 1.11\times10^{19}$ Hz.

2. $f = 102.3$ MHz. $= 1.023\times10^{8}$ Hz

Using $c = f\lambda$

$\therefore \lambda = c/f$

$\lambda = \frac{3.00\times10^{8}}{1.023\times10^{8}}$

$\lambda = 2.93$ m

3. (i) A wave is 'plane polarised' if the oscillations are all confined to one plane.

(ii) Only transverse waves can be polarised.

(iii) The plane of polarisation of an electromagnetic wave is the plane defined by the oscillation of the electric field vector ($\vec{E}$) and the direction of travel of the wave ($\vec{v}$)

(iv) When an electromagnetic wave is emitted by a dipole antenna all the electric field vectors ($\vec{E}$) are oscillating in the same direction as the rods of the antenna (as this is the direction in which the electrons in the antenna are oscillating). Thus all the oscillations of the $\vec{E}$ vectors are confined to one plane. ∴ The wave is polarised.

4. $f = 1.0$ MHz

(1). The plane of polarisation is horizontal. Electrons in the rod of the antenna are oscillating in a horizontal direction. ∴ $\vec{E}$ vectors are oscillating in a horizontal direction.

(2). $f = 1.0$ MHz. The frequency of oscillation of the $\vec{E}$ vector equals the frequency of oscillation of charges in the rods, equals the frequency of oscillation of the alternating potential difference applied to the rods.

(3). The rods of the receiving antenna must be orientated horizontally. The electric fields of the E/M waves are oscillating in a horizontal direction. ∴ They will cause the electrons in the antenna to oscillate in a horizontal direction.

(4). The electrons in a receiving antenna will oscillate with the same frequency as the $\vec{E}$ field in the E/M wave. ∴ The alternating potential difference generated in the antenna will have the same frequency as the wave. ∴ $f = 1.0$ MHz.

(5). The signal strength in the receiving antenna is greatest when the rods are aligned in the direction of polarisation of the E/M wave. ∴ if the country channels are polarised perpendicularly to city channels, country viewers can pick up their local channel (by orientating their antennae appropriately) with minimal interference from the city broadcasts.

5. (1). See text.

(2). $t_1 = 3.333\times10^{-6}$ s.

$t_2 = 3.576\times10^{-6}$ s.

(a) The first beam travels a distance $s = c\times t$

$\therefore s = 3.00\times10^{8}\times3.333\times10^{-6}$

$s = 999.9$ m

∴ height above the sea $= \frac{1}{2}s = 500$ m

(b) $\Delta t = 0.243\ \mu$s. $= 2.43\times10^{-7}$ s.

∴ extra distance travelled

$s = vt$

$= 2.234\times10^{8}\times2.43\times10^{-7}$

$= 54.3$ m

∴ depth of ocean $= s/2$

$= 27.1$ m

(3). (a) First beam travels a distance $s = ct$

$s = 3.00\times10^{8}\times2.44\times10^{-6}$

$s = 732$ m

∴ height above lake

$= 366$ m

(b) Extra distance travelled by the 'second' beam ($\Delta t = 4.56\times10^{-7}$ s)

$s = vt$

$= 2.251\times10^{8}\times4.56\times10^{-7}$

$= 102.6$ m

∴ depth of lake $= \frac{102.6}{2}$

$= 51.3$ m

(4) (a) $\Delta t = t_2 - t_1$

∴ extra distance travelled

$s = v\,\Delta t$

$= v_s(t_2 - t_1)$

∴ depth $(d) = \frac{1}{2}s$

ie $d = \frac{v_s(t_2 - t_1)}{2}$

(b) Distance travelled by 'beam 1', $s = ct_1$

∴ height above sea

$= \frac{1}{2}s$

$\therefore h = \frac{1}{2}c.t_1$

6. See notes & texts.