Question 1

Deduce the half-power beam width of a half-wave dipole antenna given that the field strength in the plane of the dipole axis is

\[ E_{\text{max}} = \frac{\cos\left(\frac{\pi}{2} \cos \theta\right)}{\sin \theta} \]

where \( \theta \) is the angle between the axis and the direction being considered.

Question 2

An antenna array consists of three vertical antennas P, Q, and R, which are spaced \( \lambda/5 \) apart along a straight line. The antennas are energised by currents of the same magnitude but of different phases. Calculate the phase relationship between the antenna currents such that maximum radiation is produced in the direction PQR. Calculate also the ratio of the power in the direction of PQR to that in the direction RQP.

Question 3

Assuming that the far-field electric field strength produced by a current element of idl is,

\[ dE_{\theta} = \frac{60\pi \text{idl}}{\\lambda r} \sin \theta \]

where \( \theta \) and \( r \) are the polar co-ordinates (see figure 1), obtain an expression for the total far-field electric field amplitude produced by a half-wave dipole excited by a terminal current \( I_m \sin \omega t \). Calculate also the power that should be fed into a half-wave dipole to produce a field of 5mV/m r.m.s at a range of 30km in a plane at right angles to the dipole axis.
Question 4

Sketch diagrams that describe the geometry and radiation patterns for the following antennas.

i. Half wave dipole in free space
ii. Horn antenna
iii. Dielectric lens antenna
iv. Wideband monopole antenna

Question 5

A multi-band antenna is required to be integrated inside the plastic case of a 3G mobile phone. The bands of service are GSM, UMTS, WiFi and Bluetooth. Sketch the input reflection coefficient and radiation pattern characteristics and suggest an antenna type that would be suitable for such an application. In your answer also highlight, the main design challenges for such an antenna.

Question 6

This question is about a 4-isotropic-element linear array with beam steering. The four elements are equally spaced by $\lambda/2$ and are excited by equal amplitude but with a progressive phase shift.

i. Calculate the phase angle required to maximise the field in the direction $\theta = 55^0$, where $\theta$ is the angle with the plane of the elements.

ii. Calculate the phase angle required to place a null in the direction $\theta = 55^0$, where $\theta$ is the angle with the plane of the elements.