1. **Antenna Recognition:**

   1. Half-Wave Dipole (b)  
   2. \(\frac{\lambda}{4}\)-Monopole (c)  
   3. Patch Antenna (h)  
   4. Folded Dipole (g)  
   5. Meandered Dipole (a)  
   6. Biconical Antenna (d)  
   7. Loop Antenna (f)  
   8. Broadband Monopole (e)

2. **Directivity:** Directivity must average to 1 over \(4\pi\) steradians. If an antenna radiates into an octant with directivity \(D_0\) and radiates into the remaining 7 octants with directivity 0, then \(D_0\) must equal 8 in the linear scale (9 dBi).

3. **Shortened Dipole:**

   (a) Neglecting the coupling between meandered horizontal segments, this resonating antenna should be \(\lambda/2\) in length when straightened.

   (b) Start with the vector magnetic potential, making the same phase approximation for the electrically short dipole:

   \[
   \tilde{A}_z(r, \theta, \phi) = \frac{\mu}{4\pi r} \exp(-jkr) \int_{-\frac{L}{2}}^{\frac{L}{2}} I \cos \frac{z'\pi}{L} \exp(jkz' \cos\theta) \, dz' = \frac{\mu IL}{2\pi^2 r} \exp(-jkr)
   \]

   From this we arrive at the far-field electric and magnetic field solutions:

   \[
   \tilde{H}(r, \phi, \theta) \approx \frac{jkIL \sin\theta}{2\pi^2 r} \exp(-jkr) \hat{\phi} \quad \tilde{E}(r, \phi, \theta) \approx \frac{jk\eta IL \sin\theta}{2\pi^2 r} \exp(-jkr) \hat{\theta}
   \]
(c) 90 degrees (identical to the Hertzian and electrically short dipoles)

(d) We need to calculate total radiated power for this:

\[ P_T = \int_0^{\pi} \int_0^{2\pi} \frac{1}{2} \hat{E} \times \hat{H} \cdot r^2 \sin \theta \, d\theta \, d\phi \hat{r} \]

\[ = \int_0^{\pi} \int_0^{2\pi} \frac{k I L \sin \theta} {2} \frac{k I L \sin \theta} {2\pi r} \frac{r^2 \sin \theta} {2\pi r} \, d\theta \, d\phi \]

\[ = \frac{2\pi}{8\pi^4} \int_0^\pi \sin^3 \theta \, d\theta \]

\[ = \frac{\eta k^2 I^2 L^2}{4\pi^3} \int_0^\pi \sin^3 \theta \, d\theta \]

\[ = \frac{\eta k^2 I^2 L^2}{3\pi^3} \]

Since \( P_T = \frac{1}{2} I^2 R_a \), then radiation resistance is solved as

\[ R_a = \frac{2\eta k^2 L^2}{3\pi^3} \]

Interestingly, this is slightly higher than the electrically short monopole. And with no reactive impedance component, this should be easier to match than the short, straight dipole.

4. Aircraft Communications:

(a) EIRP = \( P_T + G_T \) (log scale) = 11 dBW

(b) From logarithmic link budget:

\[ P_R = EIRP + G_R - 20 \log_{10} \left( \frac{4\pi}{\lambda} \right) - 20 \log_{10} r \]

where \( \lambda = 0.43 \) m at 700 MHz, \( r \) is TR separation distance, \( G_R = 6 \) dBi, and \( P_R = 114 \) dBW. Solving for \( r \) gives a range of 158 kilometers.

(c) There is a mismatch factor of 0.64 on the link (1.9 dB). All else being equal, a received power of -86 dBm now corresponds to a link distance of 120 kilometers, nearly a 20% decrease.