Question 2: Orbital Mechanics and Wave Interference

(a) Satellites in Orbit

For a satellite in a circular orbit, gravitational force equals centripetal force:

$$\frac{GM_E m}{r^2} = m\omega^2 r \implies \omega = \sqrt{\frac{GM_E}{r^3}}$$

Using $g = \frac{GM_E}{R_E^2}$, we get $\omega = R_E\sqrt{\frac{g}{r^3}}$. The radii are: $r_X = R_E + h_X = 6.36 \times 10^6 + 0.5 \times 10^6 = 6.86 \times 10^6$ m $r_Y = R_E + h_Y = 6.36 \times 10^6 + 1.0 \times 10^6 = 7.36 \times 10^6$ m The angular velocities are:

$$\omega_X = (6.36 \times 10^6)\sqrt{\frac{9.81}{(6.86 \times 10^6)^3}} \approx 1.135 \times 10^{-3}\,\text{rad/s}$$

$$\omega_Y = (6.36 \times 10^6)\sqrt{\frac{9.81}{(7.36 \times 10^6)^3}} \approx 1.002 \times 10^{-3}\,\text{rad/s}$$

The satellites are aligned again when the difference in their angular displacement is 2π:

$$(\omega_X - \omega_Y)t = 2\pi$$

$$t = \frac{2\pi}{\omega_X - \omega_Y} = \frac{2\pi}{(1.135 - 1.002) \times 10^{-3}} = \frac{2\pi}{0.133 \times 10^{-3}} \approx 47242\,\text{s}$$

In minutes, $t = \frac{47242}{60} \approx 787.4\,\text{minutes}$. **Answer:** The value of t is approximately $\mathbf{787.4}$ minutes.