SS 3011
Space Technology and Applications

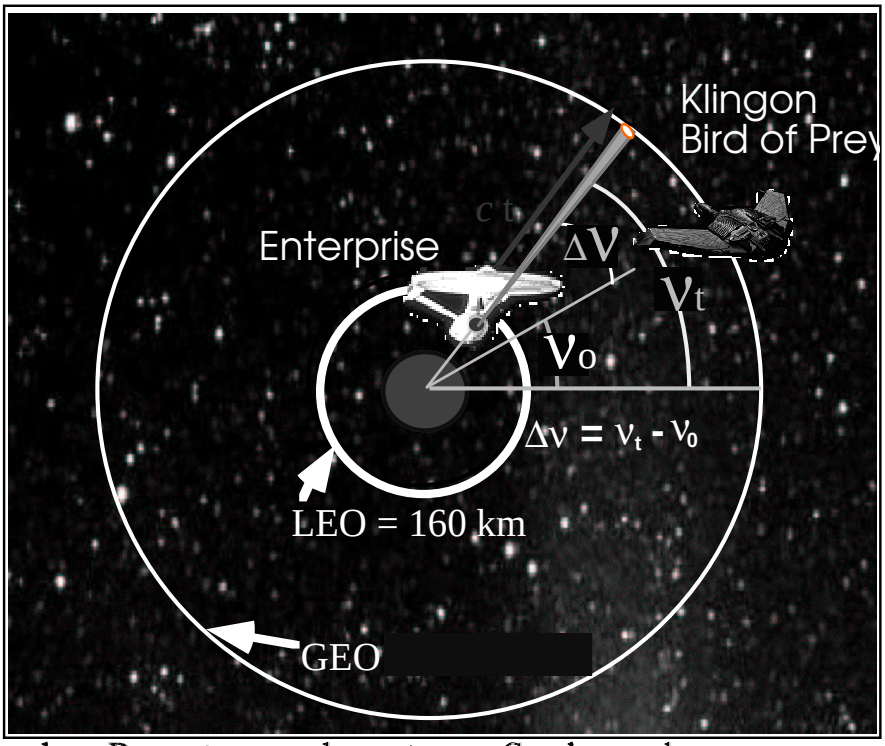
Quiz 1: October 24, 2001

Solution Notes

PROBLEM SCHEMATIC

Key to problem:

***Distance* from the Enterprise LEO to the Klingon GEO *equals* the *distance traveled* by Klingon ship in *time* it takes Phasor impulse to travel from LEO to GEO (ignore Enterprise velocity)**



First Compute Radius of Geo Orbit

- **Kepler's Third law**

$$T = \frac{2\pi a^{3/2}}{\sqrt{\mu}}$$

$$T_{geo} = 24 \text{ hrs} \times 3600 \frac{\text{sec}}{\text{hr}} = 86400 \text{ sec}$$

$$a_{geo} = \left[\frac{\sqrt{\mu}\, T_{geo}}{2\pi}\right]^{2/3} =$$

$$\left[\frac{\sqrt{3.986 \times 10^5 \frac{\text{km}^3}{\text{sec}^2}} \times 86400 \text{ sec}}{2\pi}\right]^{2/3} = \boxed{42241 \text{ km}}$$

Travel Time for Phasors from LEO Enterprise to GEO Klingon Ship

$$D_{phasor} = C_{light} \times t \cong [300{,}000 \times t]_{km} \Rightarrow t \sim \text{seconds}$$

$$t_{phasor} = \frac{D_{phasor}}{C_{light}} = \frac{R_{klingon} - R_{enterprise}}{C_{light}} = \frac{[42{,}241 - 6531]_{km}}{\left[300{,}000 \frac{\text{km}}{\text{sec}}\right]} = \boxed{0.1190 \text{ sec.}}$$

Distance Traveled by Klingon Ship in time, t_{phasor}

$$t_{phasor} = \frac{R_{klingon} - R_{enterprise}}{C_{light}} = \boxed{0.1190 \text{ sec.}}$$

$$D_{klingon} = |V_{klingon}|\, t_{phasor} = [a_{klingon}\ \omega_{klingon}]\, t_{phasor} \Rightarrow \boxed{\text{need } \omega_{klingon}}$$

$$\Downarrow$$

$$\text{GEO orbit} \Rightarrow \omega_{klingon} = \frac{2\pi \text{ radians}}{24 \text{ hours}} = \frac{2\pi \text{ radians}}{24 \text{ hours}} \times \frac{1 \text{ hour}}{3600 \text{ sec}} = \boxed{0.000072722 \frac{\text{radians}}{\text{sec}}}$$

$$\Downarrow$$

$$D_{klingon} = [a_{klingon}\ \omega_{klingon}]\, t_{phasor} =$$

$$[42241 \text{ kilometers}] \cdot \left[0.000072722 \frac{\text{radians}}{\text{sec}}\right] \cdot [0.1333 \text{ sec.}] = \boxed{0.3656 \text{ kilometers}}$$

ARC LENGTH TRAVELED

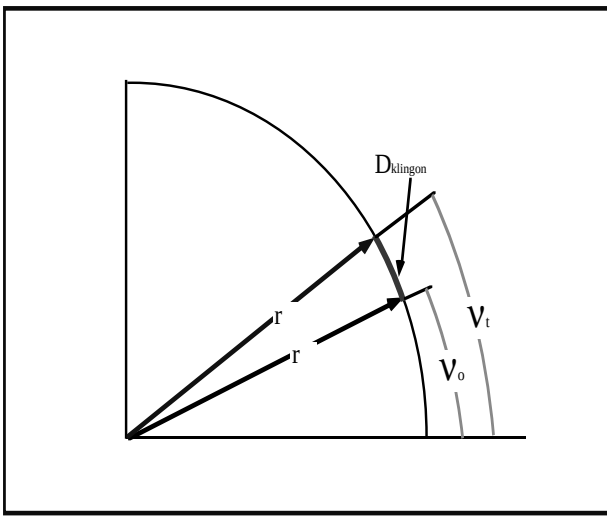
$$D_{klingon}(t_{phasor}) = \int_{\nu_1}^{\nu_t} r\, d\nu = a_{klingon}\ [\nu_t - \nu_o]$$

$$\Downarrow$$

$$\Delta\nu = \frac{D_{klingon}(t_{phasor})}{a_{klingon}} = \left[\frac{0.3656 \text{ kilometers}}{42241 \text{ kilometers}}\right] =$$

$$\left[8.655 \times 10^{-6} \text{radians}\right] \times \left[\frac{360 \text{ degrees}}{2\pi \text{ radians}}\right] =$$

$$\boxed{0.0004959 \text{ degrees}}$$



SCOTTIE'S PHASOR LEAD ANGLE

$$\Delta\nu = 0.0004959 \text{ degrees}$$

- **KIRK WAS ALMOST RIGHT!**