PROBLEM SET 11 SOLUTIONS Physics 2021

1. The time between oppositions is the synodic period.

E = 1 yr P = 1.88 yr P⁻¹ = E⁻¹ - S⁻¹ S⁻¹ = E⁻¹ - P⁻¹ S⁻¹ = 1 - (1.88)⁻¹ = 0.468 S = 2.14 years (Earth Orbits) 2.14 / 1.88 = 1.14 (Mars Orbits)

- 2. Mars appears Full; Earth appears as a crescent (or not seen at all).
- **3a.** Valles Marineris is not an erosional feature it is a rift caused by the rise of the Tharsis bulge.
- **3b.** "Grand Canyon of Mars" is not an appropriate description of Valles Marineris because it is much larger than the Grand Canyon and because of the statements in answer (a).
- 4. Although it is colder at the poles, there is water ice. The chance of life on Mars at any location is extremely low, though.
- 5. $P = 7 hr 39 min = 8.727 x 10^{-4} yr$
 - $a = (6000 \text{ km} + 3397 \text{ km}) = 9397 \text{ km} = 6.265 \text{ x} 10^{-5} \text{ AU}$

 $(\mathcal{M}_{mars} + \mathcal{M}_{phobos}) \mathbf{P}^2 = \mathbf{a}^3$

 $\mathcal{M}_{\text{mars}} = (6.265 \text{ x } 10^{-5})^3 / (8.727 \text{ x } 10^{-4})^2 = 3.228 \text{ x } 10^{-7} \text{ solar masses}$

 $\mathcal{M}_{\text{mars}} = 6.42 \text{ x } 10^{23} \text{ kg}$ Compares well

6. Phobos: $\tan \alpha = D / d = (28 \text{ km}) / (6000 \text{ km})$ $\alpha = 4.67 \text{ x } 10^{-3} \text{ rad} = 16 \text{ arcmin}$ Deimos: $\tan \alpha = D / d = (16 \text{ km}) / (20,000 \text{ km})$ $\alpha = 8.00 \text{ x } 10^{-4} \text{ rad} = 3 \text{ arcmin}$ (The results are maximum values because the longest dimension was used in the calculation.) Phobos and Deimos would not be as impressive as our Moon, which subtends 30 arcmin.

7.
$$r_{min} = a (1 - e) = 1.523 (1 - 0.093) = 1.523 (0.907) = 1.38 \text{ AU}$$

 $r_{max} = a (1 + e) = 1.523 (1 + 0.093) = 1.523 (1.093) = 1.66 \text{ AU}$
Smallest opposition distance = 1.38 AU - 1.00 AU = 0.38 AU
Largest opposition distance = 1.66 AU - 1.00 AU = 0.66 AU

8.
$$d = 0.52 \text{ AU}$$
 $\theta = 1 \text{ arcsec}$ $\tan \theta = D / d$

 $D = d \tan \theta = (0.52 \text{ AU}) (1.5 \text{ x } 10^8 \text{ km/AU}) \tan (1/3600) = 378 \text{ km}$

Diameter of Mars = 6,787 km

so D = 5.6% of Mars' diameter

9a. D = d tan
$$\alpha$$
 = tan[(1.0 arcsec) π / (180 x 60 x 60)] (88.1 x 10⁶ km) = 427 km

9b. D = d tan α = tan[(0.1 arcsec) π / (180 x 60 x 60)] (88.1 x 10⁶ km) = 42.7 km