## PROBLEM SET 11 SOLUTIONS <br> Physics 2021

1. The time between oppositions is the synodic period.
$\mathbf{E}=1 \mathbf{y r}$
$\mathrm{P}=1.88 \mathrm{yr}$
$\mathbf{P}^{-1}=\mathbf{E}^{-1}-\mathbf{S}^{-1}$
$\mathbf{S}^{\mathbf{1}}=\mathbf{E}^{-\mathbf{1}}-\mathbf{P}^{\mathbf{- 1}}$
$S^{-1}=1-(1.88)^{-1}=0.468$
$S=2.14$ years $\quad$ (Earth Orbits)
$2.14 / 1.88=1.14 \quad$ (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. $\quad P=7 \mathrm{hr} 39 \mathrm{~min}=8.727 \times 10^{-4} \mathrm{yr}$

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\begin{aligned}
\mathrm{a}=(6000 \mathrm{~km} & +3397 \mathrm{~km})=9397 \mathrm{~km}=6.265 \times 10^{-5} \mathrm{AU} \\
& \left(\mathcal{M}_{\text {mars }}+\mathcal{M}_{\text {phobos }}\right) \mathrm{P}^{2}=\mathrm{a}^{3} \\
& \mathcal{M}_{\text {mars }}=\left(6.265 \times 10^{-5}\right)^{3} /\left(8.727 \times 10^{-4}\right)^{2}=3.228 \times 10^{-7} \text { solar masses } \\
& \mathcal{M}_{\text {mars }}=6.42 \times 10^{23} \mathrm{~kg} \quad \text { Compares well }
\end{aligned}
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6. $\quad$ Phobos: $\tan \alpha=D / d=(28 \mathrm{~km}) /(6000 \mathrm{~km}) \quad \alpha=4.67 \times 10^{-3} \mathrm{rad}=16 \mathrm{arcmin}$

Deimos: $\tan \alpha=D / d=(16 \mathrm{~km}) /(20,000 \mathrm{~km}) \quad \alpha=8.00 \times 10^{-4} \mathrm{rad}=3 \operatorname{arcmin}$ (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. $\quad r_{\text {min }}=\mathbf{a}(1-\mathrm{e})=1.523(1-0.093)=1.523(0.907)=1.38 \mathrm{AU}$
$r_{\text {max }}=a(1+e)=1.523(1+0.093)=1.523(1.093)=1.66 \mathrm{AU}$
Smallest opposition distance $=1.38 \mathrm{AU}-1.00 \mathrm{AU}=0.38 \mathrm{AU}$
Largest opposition distance $=1.66 \mathrm{AU}-1.00 \mathrm{AU}=0.66 \mathrm{AU}$
8. $d=0.52 \mathrm{AU} \quad \theta=1 \operatorname{arcsec} \quad \tan \theta=\mathrm{D} / \mathrm{d}$
$D=d \tan \theta=(0.52 \mathrm{AU})\left(1.5 \times 10^{8} \mathrm{~km} / \mathrm{AU}\right) \tan (1 / 3600)=378 \mathrm{~km}$
Diameter of Mars $=\mathbf{6 , 7 8 7} \mathbf{k m}$

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\text { so } D=5.6 \% \text { of Mars' diameter }
$$

9a. $D=d \tan \alpha=\tan [(1.0 \operatorname{arcsec}) \pi /(180 \times 60 \times 60)]\left(88.1 \times 10^{6} \mathrm{~km}\right)=427 \mathrm{~km}$
9b. $\quad D=d \tan \alpha=\tan [(0.1 \operatorname{arcsec}) \pi /(180 \times 60 \times 60)]\left(88.1 \times 10^{6} \mathrm{~km}\right)=42.7 \mathrm{~km}$

