## PROBLEM SET 10 SOLUTIONS Physics 2021

1. $\quad$ Maximum distance of Mercury from the Sun $=6.98 \times 10^{7} \mathbf{~ k m}$ Minimum distance of Earth from the Sun $=1.471 \times 10^{8} \mathbf{~ k m}$

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\text { Difference }=7.73 \times 10^{7} \mathrm{~km}
$$

$$
\begin{aligned}
\text { Angle } & =\text { diameter } / \text { distance }=4879 \mathrm{~km} / 7.73 \times 10^{7} \mathrm{~km} \\
& =6.31 \times 10^{-5} \mathrm{rad}=13 \mathrm{arcsec}
\end{aligned}
$$

Must be at Inferior Conjunction.
2. $\quad$ Angle $=1 \operatorname{arcsec} \times[\pi(\operatorname{rad}) /(180 \times 60 \times 60 \operatorname{arcsec})]=4.848 \times 10^{-6} \mathbf{r a d}$ Distance $=\left(1.5 \times 10^{8} \mathrm{~km}\right) \cos 28^{\circ}=1.32 \times 10^{8} \mathrm{~km}$

Angle $=$ diameter $/$ distance
Diameter $=$ angle $\times$ distance $=\left(4.848 \times 10^{-6}\right)\left(1.32 \times 10^{8} \mathrm{~km}\right)=640 \mathrm{~km}$ Caloris Basin is 1500 km, so it can be resolved.
3. $m=80 \mathrm{~kg}$
$\mathcal{M}_{\text {Mercury }}=3.302 \times 10^{\mathbf{2 3}} \mathbf{~ k g}$
$\mathbf{R}=2440 \mathrm{~km}$
$\mathbf{W}=\mathbf{G m} \mathcal{M}_{\text {Mercury }} / \mathbf{R}^{\mathbf{2}}$
$=\left(6.67 \times 10^{-11} \mathrm{~N} \mathrm{~m}^{2} / \mathrm{kg}^{2}\right)(80 \mathrm{~kg})\left(3.302 \times 10^{23} \mathrm{~kg}\right) /\left(2440 \times 10^{3} \mathrm{~m}\right)^{2}$
$=295.9 \mathrm{~N}$

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\begin{aligned}
\mathrm{m}= & 80 \mathrm{~kg} \quad \mathcal{M} \text { moon }=7.348 \times 10^{22} \mathrm{~kg} \quad \mathrm{R}=1738 \mathrm{~km} \\
& \mathrm{~W}=\mathrm{G} \mathrm{~m} \mathcal{M}_{\text {moon }} / \mathrm{R}^{2} \\
= & \left(6.67 \times 10^{-11} \mathrm{~N} \mathrm{~m}^{2} / \mathrm{kg}^{2}\right)(80 \mathrm{~kg})\left(7.348 \times 10^{22} \mathrm{~kg}\right) /\left(1738 \times 10^{3} \mathrm{~m}\right)^{2} \\
= & 129.8 \mathrm{~N}
\end{aligned}
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$$
\begin{aligned}
\mathrm{m}= & 80 \mathrm{~kg} \quad \mathcal{M}_{\text {earth }}=5.974 \times 10^{24} \mathrm{~kg} \quad \mathrm{R}=6378 \mathrm{~km} \\
& \mathrm{~W}=\mathrm{Gm} \mathcal{M}_{\text {earth }} / \mathrm{R}^{2} \\
= & \left(6.67 \times 10^{-11} \mathrm{~N} \mathrm{~m}^{2} / \mathrm{kg}^{2}\right)(80 \mathrm{~kg})\left(5.974 \times 10^{24} \mathrm{~kg}\right) /\left(6378 \times 10^{3} \mathrm{~m}\right)^{2} \\
= & 783.6 \mathrm{~N}
\end{aligned}
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On Mercury, one would weigh more than on the Moon but less than on the Earth.
4. The surface gravity on Mercury is more than twice as great as that of the Moon. Consequently, for identical cratering impacts on these two worlds, the ejecta on Mercury cannot travel as far because more energy would be needed to counteract the stronger gravitational pull.
5. Mercury's orbital period $=\mathbf{8 7 . 9 6 9}$ days

Mariner 10's orbital period $=87.969 \times 2=175.9$ days $=0.4817$ years

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\begin{aligned}
\mathbf{P}^{2}=\mathbf{a}^{3} & =(0.4817 \mathrm{yr})^{2}=0.2320 \mathrm{yr}^{2} \\
\mathbf{a} & =0.6145 \mathrm{AU}
\end{aligned}
$$

6. (a) The surface of Mercury is rocky (mid- and low-density stones), but the average density suggests that a large amount of iron is present in the planet. Because no iron is at the surface, it has settled to the center causing a differentiated structure. (b) The presence of a magnetic field also suggests a differentiated planet.
7. It takes a substantially longer time for Venus to go from a greatest western elongation to a greatest eastern elongation. During its trek, Venus is at its maximum distance from us. Because its orbital speed is not much greater than the Earth's, Venus takes a long time to go between these two angular positions. On the other hand, as Venus goes from a greatest eastern elongation to a greatest western elongation, it is near the Earth and quickly overtakes it, going from the evening sky to the morning sky in a relatively shorter amount of time.
8. The Synodic Period of Venus (based on alignment of the moving Earth and the Sun) is $\mathbf{5 8 4}$ days. The Sidereal Period, based on the stars, is $\mathbf{2 2 4 . 7}$ days.
9. Longer wavelengths of light (infrared is longer than red light) can more easily pass through clouds and gases. It was necessary to use infrared wavelengths to observe the lower clouds because the upper clouds absorb visible light from those clouds.
10. If a planet's atmosphere were opaque to visible light but transparent to infrared radiation, it would be a cool/cold world. Because the shorter-wavelength visible light cannot reach the surface, it does not heat up much. And, if it did, its reradiated heat would be in the infrared, which would easily pass through the atmosphere. This type of cooling is exactly opposite that of the "greenhouse effect" that occurs in the atmosphere of Venus.
