Chap 11 review

1. Knowing that $g = 9.80\ \frac{\text{m}}{\text{s}^2}$ at sea level and that $R_E = 6.37 \times 10^6$ m, we find that the value of g in $\frac{\text{m}}{\text{s}^2}$ at a distance R_E from the surface of the Earth is

a. 1.23. b. 2.45. c. 4.90. d. 7.35 e. 9.80 ANS: B

1. B. $\because g = \frac{GM_E}{R_E}$. $g' = \frac{GM_E}{(2R_E)^2} = g/4 = \frac{9.8}{4} = 2.45\ \text{m/s}^2$

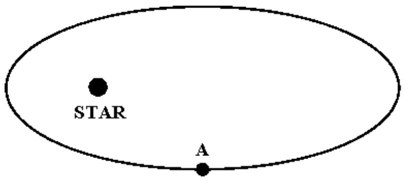
2. The period of a satellite circling planet Nutron is observed to be 84 s when it is in a circular orbit with a radius of 8.0×10^6 m. What is the mass of planet Nutron?

a. 6.2×10^{28} kg b. 5.0×10^{28} kg c. 5.5×10^{28} kg
d. 4.3×10^{28} kg e. 3.7×10^{28} kg ANS: D

2. D. circular orbit $\frac{mv^2}{r} = \frac{\cancel{m}4\pi^2 r}{T^2} = \frac{G\cancel{m}M_N}{r^2}$

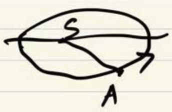
$\Rightarrow M_N = \frac{4\pi^2 r^3}{GT^2} = \frac{4\pi^2(8\times10^6)^3}{6.67\times10^{-11}\times 84^2} = 4.29\times10^{28}$

3. The figure below shows a planet traveling in a counterclockwise direction on an elliptical path around a star located at one focus of the ellipse. When the planet is at point A,



a. its speed is constant. b. its speed is increasing c. its speed is decreasing
d. its speed is a maximum. e. its speed is a miinimum ANS: C

3. C.



$r\uparrow \Rightarrow v\downarrow$

4. An asteroid revolves around the Sun with a perihelion 0.5 AU and an aphelion of 7.5 AU. What is its period of revolution?

a. 4 years b. 8 years c. 16 years d. 32 years e. 64 years ANS: B

4. B. 1AU ~ ave distance from earth to sun
Perihelion = 近日点. aphelion: 遠日点
for earth $\frac{a^3}{T^2} = \frac{(1\,\text{AU})^3}{1\,\text{yr}^2} = \frac{\left(\frac{0.5+7.5}{2}\,\text{AU}\right)^3}{T^2} = \frac{64}{T^2}$

$\Rightarrow T = 8$ yrs.

5. A spacecraft (mass = m) orbits a planet (mass = M) in a circular orbit (radius = R). What is the minimum energy required to send this spacecraft to a distant point in space where the gravitational force on the spacecraft by the planet is negligible?

a. $GmM/(4R)$ b. GmM/R c. $GmM/(2R)$ d. $GmM/(3R)$ e. $2GmM/(5R)$ ANS: C

5. C.  $E_R = -\frac{GMm}{2R}$. go to ∞, total $E = 0$

$\Rightarrow \Delta E = 0 - E_R = GMm/2R$

6. An object is released from rest at a distance h above the surface of a planet (mass = M, radius = $R < h$). With what speed will the object strike the surface of the planet? Disregard any dissipative effects of the atmosphere of the planet.

a. $\left[\frac{2GMh}{R(R+h)}\right]^{1/2}$ b. $\left[\frac{2GM}{R}\right]^{1/2}$ c. $\left[\frac{2GM(h-R)}{Rh}\right]^{1/2}$ d. $\left[\frac{2GM}{R+h}\right]^{1/2}$

e. $\left[\frac{2GM}{R-h}\right]^{1/2}$ ANS: A

6. A.  $E_{mech} = K + U_g = 0 - \frac{GMm}{(R+h)} = \frac{1}{2}\cancel{m}v^2 - \frac{GM\cancel{m}}{R}$

$\Rightarrow v^2 = 2\left(\frac{GM}{R} - \frac{GM}{R+h}\right) = 2GM\frac{h}{R(R+h)}$

$\therefore v = \sqrt{2GMh/R(R+h)}$.

7. Planet Zero has a mass of 5.0×10^{23} kg and a radius of 2.0×10^{6} m. A space probe is launched vertically from the surface of Zero with an initial speed of 4.0 km/s. What is the speed of the probe when it is 3.0×10^{6} m from Zero's center?

a. 3.0 km/s b. 2.2 km/s c. 1.6 km/s d. 3.7 km/s e. 5.9 km/s ANS:B

7. B.  $E_{mech} = \frac{1}{2}\cancel{m}(4\ \text{km/s})^2 - \frac{GM\cancel{m}}{R}$

$M = 5\times10^{23}$ kg. $R = 2\times10^{6}$ m $= \frac{1}{2}\cancel{m}v^2 - GM\cancel{m}/3\times10^{6}$

$\Rightarrow v^2 = 16\times10^{6} + 2GM\left(\frac{1}{3\times10^{6}} - \frac{1}{2\times10^{6}}\right) = 4.9\times10^{6}$

$\Rightarrow v = \sqrt{4.9}\times10^{3} = 2.2$ km/s

8. The escape velocity at the surface of Earth is approximately 11 km/s. What is the mass, in units of M_E (the mass of the Earth), of a planet with twice the radius of Earth for which the escape speed is twice that for Earth?

A) 2 M_E B) 4 M_E C) 8 M_E D) 1/2 M_E E) 1/4 M_E Ans: C

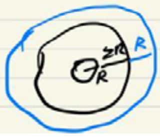
8. C. $V_{esc} = \sqrt{\frac{2GM_E}{R_E}}$. $V'_{esc} = \sqrt{\frac{2GM}{\cancel{2}R_E}} = 2V_{esc} = 2\sqrt{\frac{2GM_E}{R_E}}$

$\Rightarrow M = 8M_E$

9. A satellite of mass *m* circles a planet of mass *M* and radius *R* in an orbit at a height 2*R* above the surface of the planet. What minimum energy is required to change the orbit to one for which the height of the satellite is 3*R* above the surface of the planet? ANS: A

a. $\frac{GmM}{24R}$ b. $\frac{GmM}{15R}$ c. $\frac{GmM}{12R}$ d. $\frac{2GmM}{21R}$ e. $\frac{3GmM}{5R}$

9. A.



$E_i = \frac{U_i}{2} = \frac{-GMm}{2\times 3R}$, $E_f = \frac{U_f}{2} = \frac{-GMm}{2\times 4R}$

$\Rightarrow E_f - E_i = \frac{GMm}{R}\left(\frac{1}{6} - \frac{1}{8}\right) = GMm/24R$

10. An energy of 13.6 eV is needed to ionize an electron from the ground state of a hydrogen atom. Selecting the longest wavelength that will work from the those given below, what wavelength is needed if a photon accomplishes this task?

a. 60 nm b. 80 nm c. 70 nm d. 90 nm e. 40 nm ANS: D

10. D. $13.6eV = hf = hc/\lambda \Rightarrow \lambda = \frac{hc}{13.6eV} = \frac{4.14\times10^{-15} eV\cdot s \cdot 3\times10^{8} m/s}{13.6 eV}$

$\Rightarrow \lambda = 0.913\times10^{-7} m = 91.3 nm$

11. For the following allowed transitions, which photon would have the largest wavelength when an electron "jumps" from one energy level, characterized by the quantum number *n*, to another?

a. $n = 2$ to $n = 1$

b. $n = 3$ to $n = 2$

c. $n = 3$ to $n = 1$

d. $n = 1$ to $n = 3$

e. $n = 4$ to $n = 1$ ANS: B

11. B. for $E_n = \frac{-13.6}{n^2}$ $\therefore$ $\boxed{n = 2\to1}$, $E_2 - E_1 = -13.6\left(\frac{1}{2^2} - \frac{1}{1}\right) = \underline{13.6\times\frac{3}{4}}$

$\boxed{n = 3\to2}$, $E_3 - E_2 = -13.6\left(\frac{1}{3^2} - \frac{1}{2^2}\right) = 13.6\times\frac{5}{36}$

$\boxed{n = 3\to1}$, $E_3 - E_1 = -13.6\left(\frac{1}{3^2} - 1\right) = \boxed{13.6\times 8/9}$

$n = 1\to3$ $= E_1 - E_3 = -13.6\times 8/9$

$n = 4\to1$ $= 13.6\left(1 - \frac{1}{4^2}\right) = 13.6\ 15/16$

for $\Delta E = hf = \frac{hc}{\lambda}$ $\therefore \Delta E\uparrow, \lambda\downarrow \Rightarrow \min\lambda: n = 3\to2$

12. Suppose a beam of electrons is incident on a collection of hydrogen atoms, all of which are in the lowest energy state (n = 1). What is the minimum energy the electrons can have if they are to excite the hydrogen atoms into the n = 2 state?

ANS: 10.2 eV

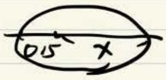
12. $\Delta E(n=2\to 1) = -13.6\left(\frac{1}{2^2}-1\right) = 13.6 \times \frac{3}{4} = 10.2\,\text{eV}$

e^- need 10.2eV to excite H atom from $n=1\to 2$

13. An asteroid revolves around the Sun with a period of 8 years. If its perihelion is 0.5 AU find the aphelion of the asteroid. Note, 1 AU is the average distance between the Earth and the Sun.

A. 4 .5 AU B. 6.0 AU C. 7.5 AU D. 8.5 AU E. 9.5 AU

13. C.



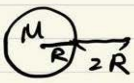
$\because \frac{a^3}{T^2} = \text{const} = \frac{(1\,\text{AU})^3}{1\,\text{yr}^3} = \left[\frac{0.5+x}{2}\right]^3 / 8^2$

$\therefore \left(\frac{0.5+x}{2}\right)^3 = 64 = 4^3 \therefore 0.5+x=8 \therefore x = 7.5\,\text{AU}.$

14. An object is released from rest at a distance 2R above the surface of a planet (mass = M, radius = R). With what speed will the object strike the surface of the planet? Disregard any dissipative effects of the atmosphere of the planet.

A. $\sqrt{\frac{2GM}{3R}}$ B. $\sqrt{\frac{GM}{R}}$ C. $\sqrt{\frac{4GM}{3R}}$ D. $\sqrt{\frac{5GM}{3R}}$ E. $\sqrt{\frac{2GM}{R}}$

14. C.



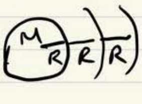
$\therefore E = K+U = 0 - \frac{GM\cancel{m}}{3R} = \frac{1}{2}\cancel{m}v^2 - \frac{GM\cancel{m}}{R}$

$\Rightarrow \frac{1}{2}v^2 = \frac{GM}{R}\left(1-\frac{1}{3}\right) = \frac{GM}{R}\cdot\frac{2}{3} \Rightarrow v = \sqrt{\frac{4GM}{3R}}$

15. A satellite of mass m circles a planet of mass M and radius R in an orbit at a height R above the surface of the planet. What minimum energy is required to change the orbit to one for which the height of the satellite is 2R above the surface of the planet?

A. $\frac{GmM}{24R}$ B. $\frac{GmM}{15R}$ C. $\frac{GmM}{12R}$ D. $\frac{GmM}{9R}$ E. $\frac{GmM}{8R}$

15. C.



circular orbit $E = U/2$

$\therefore E_i = \frac{-GMm}{2\times 2R}$. $E_f = \frac{-GMm}{2\times 3R}$. $\Delta E = E_f - E_i = \frac{GMm}{R}$

$\therefore \Delta E = E_f - E_i = \frac{GMm}{R}\left(\frac{1}{4}-\frac{1}{6}\right) = \frac{GMm}{12R}$