Smith's Key

A.P. Physics – C

UNIT 6 TEST REVIEW

Gravitation & Oscillation
Chapters 13 & 15

*** In studying for your test, make sure to study this review sheet <u>along with your quizzes and homework assignments.</u>**

Multiple Choice Review: **On this portion of the test, you will not be allowed to use your calculator or AP formula sheet. (You may, however, use your AP table of information.) Approximate $g=10m/s^2$ for simplicity of calculations. No partial credit will be given.**

1. A new planet is discovered that has twice the Earth's mass and twice the Earth's radius. On the surface of this new planet, a person who weighs 500N on Earth would experience a gravitational force of...

   a. 125N (b.) 250N c. 500N d. 1000N e. 2000N

   $F = \frac{Gmm}{r^2}$ $F' = \frac{Gm(2m)}{(2r)^2} = \frac{1}{2}F$

2. What is the orbital speed of a satellite of mass m orbiting the earth at a distance r from the center of the Earth? (Assume that G stands for the gravitational constant and M stands for the Earth's mass.)

   a. $\frac{GM}{r}$ b. $\sqrt{\frac{2GM}{r}}$ c. $\frac{2Gm}{r}$ d. $\sqrt{\frac{2Gm}{r}}$ (e.) $\sqrt{\frac{GM}{r}}$

   $F_g = mv^2/r \rightarrow \frac{GmM}{r^2} = \frac{mv^2}{r} \rightarrow v = \sqrt{\frac{GM}{r}}$

3. Which one of the following would be the correct value for the escape speed for a 2kg object from a 20,000kg asteroid of radius 100m? (All answers are in meters per second.)

   a. 20G b. 400G c. $2\sqrt{G}$ (d.) $20\sqrt{G}$ e. $\sqrt{50G}$

   $KE_i + U_i = \emptyset$; $\frac{1}{2}mv_i^2 - \frac{GmM}{r} = \emptyset$; $\frac{1}{2}mv^2 = \frac{GmM}{r} \rightarrow v = \sqrt{\frac{2GM}{r}} = \sqrt{\frac{2G(20000)}{100}} = \sqrt{\frac{40{,}000G}{100}} = \sqrt{400G} = 20\sqrt{G}$

4. A rock of mass m is a distance R above the surface of a planet. If the planet has a mass of M and radius also equal to R, what is the value of g at the location of the rock?

   a. $\frac{GM}{R^2}$ b. $\frac{Gm}{R^2}$ c. $\frac{GM}{2R^2}$ d. $\frac{Gm}{2R^2}$ (e.) $\frac{GM}{4R^2}$

   $mg = G\frac{mM}{r^2} = \frac{G(M)}{(2R)^2} = \frac{GM}{4R^2}$

$U_i = -\frac{G(1)(1)}{1} = -G$ $U_f = -\frac{G(1)(1)}{2} = -\frac{1}{2}G$ $\Delta U = U_f - U_i = -\frac{1}{2}G - -G = G/2$

5. Two 1kg masses are in distant outer space at a distance of 1m apart from each other. How much work must you do to move them to a distance of 2m apart?

a. G (b.) $\frac{G}{2}$ c. $\frac{G}{4}$ d. $2G$ e. $4G$

6. A 10kg mass is attached to a string of length 40m, and hung down from a rooftop to make a long pendulum. If the pendulum is set into simple harmonic motion, what is its period of vibration?

a. $\pi/2$ seconds
b. π seconds
c. 2π seconds
(d.) 4π seconds
e. 8π seconds

$T = 2\pi\sqrt{\frac{40}{10}} = 4\pi$

7. A mass attached to a spring is vibrating with simple harmonic motion according to the following equation: $x = (0.4)\cos(8\pi t)$ → $8\pi = 2\pi f \rightarrow f = 4 \rightarrow T = 1/f = 0.25$
Assuming all quantities are measured in S.I. units, what is the period of vibration of the mass?

(a.) 0.25s b. 0.4s c. 2s d. 4s e. 8s

8. A simple pendulum and a mass hanging on a spring both have a period of 1s when set into small oscillatory motion on Earth. They are taken to Planet X, which has the same diameter as Earth but twice the mass. Which of the following statements is true about the periods of the two objects on Planet X compared to their periods on Earth?

$g = \frac{GM}{r^2}$ so $g' = 2g$ and $T = 2\pi\sqrt{L/g}$ (pend) so T decreases

a. Both are shorter.
b. Both are the same.
c. Both are longer.
d. The period of the mass on the spring is shorter; that of the pendulum is the same.
(e.) The period of the pendulum is shorter; that of the mass on the spring is the same.

$T = 2\pi\sqrt{\frac{m}{k}}$ so g doesn't matter.

[redacted]

9. A mass is attached to a spring and set into simple harmonic motion. Which one of the following statements is true about the mass?

a. The mass has minimum kinetic energy when it is at equilibrium. (max KE @ equil)
b. The mass has maximum velocity when it is at its amplitude. (min v @ A)
c. The total mechanical energy of the mass is greater when it is at equilibrium than at its amplitude. (ME constant)
d. The mass experiences the maximum restoring force at equilibrium. ($F = -kx$ so $F = 0$ @ equil)
(e.) The mass has maximum acceleration when it is at its amplitude.

Since $F = -kx$, F max when @A, so accel also @ max @A. (or $a = -\omega^2 x$)

10. A block attached to the lower end of a vertical spring oscillates up and down. If the spring obeys Hooke's law, the period of oscillation depends on which of the following?

I. Mass of the block
II. Amplitude of the vibration
III. Force constant of the spring

$T = 2\pi\sqrt{\frac{m}{k}}$

a. I only
b. II only
c. III only
d. I and II
(e.) I and III

Problem Review: On this portion of the test, you may use your calculator, AP formula sheet, and AP table of information. Partial credit will be given on these problems.

Body	Mass (kg)	Mean Radius (m)	Distance from Sun (m)
Earth	5.98×10^{24}	6.37×10^{6}	1.496×10^{11}
Sun	1.991×10^{30}	6.96×10^{8}	--
Moon	7.36×10^{22}	1.74×10^{6}	--

* Distance from the Earth's surface to the Moon's surface = 384,000 km

11. Use the given information in the table to determine...

a. the gravitational force between the Moon and Earth.

$F_g = \frac{G(5.98E^{24})(7.36E^{22})}{(3.84E^{8} + 6.37E^{6} + 1.74E^{6})^2} = 1.909\times10^{20}\ N$

$\nwarrow 3.92E^{8}$

b. the orbital speed of the Moon around the Earth.

$F_g = ma_c$ (v^2/r)

$1.909\times10^{20} = (7.36E^{22})(v^2/3.92E^{8}) \rightarrow v = 1008\ m/s$

c. the period of orbit of the Moon.

$v = \frac{d}{t} = \frac{2\pi r}{T}$

$1008 = \frac{2\pi(3.92E^{8})}{T} \rightarrow T = 2,442,403\ s$

$= 678.4$ hours

$= 28.3$ days

12. A 5kg rock is released from rest at a distance of 20m above the surface of a certain spherical asteroid. If the asteroid's mass is ~~120,000~~ 7,500,000 kg and its radius is 58m, how fast is the rock moving when it strikes the asteroid's surface?

$U_i = U_f + KE_f$

$-\frac{GMm}{r+h} = -\frac{GMm}{r} + \frac{1}{2}mv^2$

$\frac{-G(7{,}500{,}000)}{25.8} = \frac{-G(7{,}500{,}000)}{5.8} + \frac{1}{2}v^2$

$\frac{1}{2}v^2 = 6.69E^{-4}$

$v = 3.7\ cm/s$

13. For the same asteroid as discussed in #12, calculate its escape speed.

$KE_i + U_i = 0$ ← @∞

$\frac{1}{2}(m)(v_{esc}^2) = \frac{G(m)(M)}{r}$

$v_{esc} = \sqrt{\frac{2GM}{r}}$

$= \sqrt{\frac{2G(7{,}500{,}000)}{5.8}} = 1.3\frac{cm}{s}$

14. A 5kg rod is hung from a 10cm-long vertically-oriented spring, and stretches the spring an additional 3cm from equilibrium.

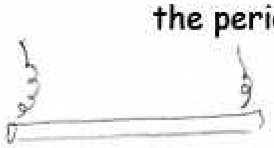
a. Calculate the k-value of the spring.

$F = -kx$

$5(9.8) = -k(-.03)$

$k = 1633\ N/m$

b. Now an additional identical spring is connected, so that the rod is supported by a spring at both ends. If it is set into oscillation, what is the period of its motion?



$k_{effective} = \frac{1}{2}(1633) = 817\ N/m$

$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{5}{817}} = 0.49\ s$

15. Calculate the frequency of motion for a 10kg simple pendulum with a length of 75cm.

$T = 2\pi\sqrt{L/g} = 2\pi\sqrt{\frac{.75}{9.8}} = 1.74\ s$

$f = 1/T = 0.58\ Hz$

16. A spring (k=19.6N/m) is connected to a 3kg mass, making a horizontal mass-spring system. If the system is compressed 5cm and released from rest, find the following:

a. The maximum speed of the mass.

@ equil, no U

@ amplitude, no KE

$$\frac{1}{2}kA^2 = \frac{1}{2}mv_{max}^2$$

$$\frac{1}{2}(19.6)(.05)^2 = \frac{1}{2}(3)(v_{max}^2) \longrightarrow v_{max} = 12.8\frac{cm}{s}$$

b. The x-location (distance from equilibrium) where the speed of the mass is 1/3 its maximum speed.

$$\frac{1}{2}kA^2 = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$$

$$\frac{1}{2}(19.6)(.05^2) = \frac{1}{2}(19.6)x^2 + \frac{1}{2}(3)\left(\frac{.128}{3}\right)^2$$

$$x = .047m$$

17. A simple harmonic oscillator is moving with an amplitude of 8cm and frequency of 9.2Hz. Calculate the maximum velocity and acceleration of the oscillator.

$$x = A\cos\omega t$$

$$v = \frac{dx}{dt} = -\omega A\sin\omega t$$

$$a = \frac{dv}{dt} = -\omega^2 A\cos\omega t$$

$$\omega = 2\pi f = 2\pi(9.2) = 57.81\frac{rad}{s}$$

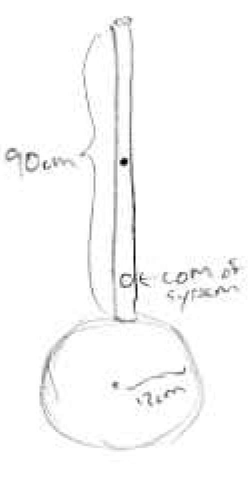
$$v_{max} = -(57.81)(.08)\sin\omega t \;(\sin\omega t \to 1)$$

$$= 4.62 m/s$$

$$a_{max} = -(57.81^2)(.08)\cos\omega t \;(\cos\omega t \to 1)$$

$$= 267.4 m/s^2$$

18. A 2kg sphere with a radius of 12cm is suspended from one end of a long thin rod that is free to pivot about an axis through its center. Calculate the period of its motion, if the rod has a mass of 800g and a length of 90cm.



$$I = \underbrace{\frac{1}{12}mL^2}_{rod} + \underbrace{2/5mr^2 + mh^2}_{sphere\ w/shift}$$

$$= \frac{1}{12}(.8)(.9^2) + \frac{2}{5}(2)(.12^2) + (2)(.57^2)$$

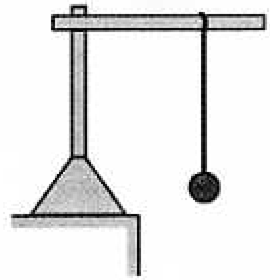
$$= .054 + .0115 + .6498 = .7153 kgm^2$$

$$COM = \frac{1}{2.8}((2)(.57) + (.8)(0)) = .407m$$

$$T = 2\pi\sqrt{\frac{I}{mgd}} = 2\pi\sqrt{\frac{.7153}{(2.8)(9.8)(.407)}}$$

$$= 1.59s$$

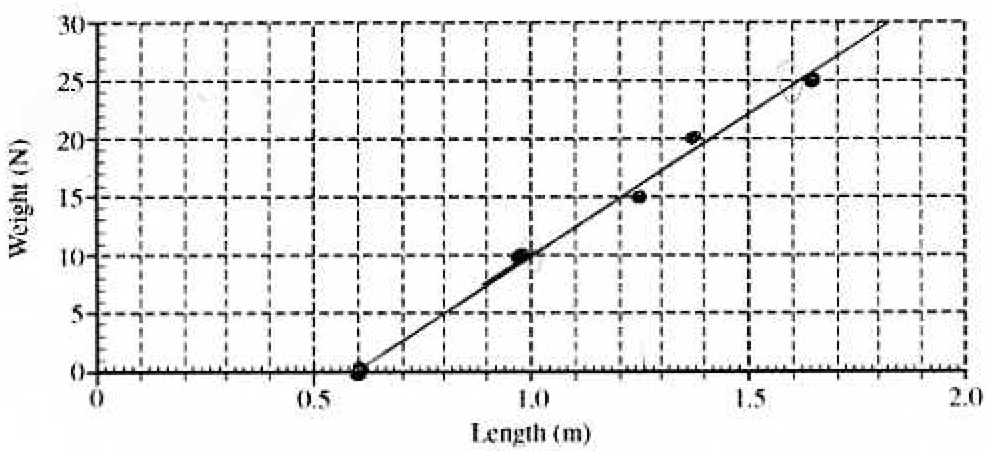
19. **Actual A.P. Physics C Free-Response Question, sort of (2008):**



In an experiment to determine the spring constant of an elastic cord of length 0.60 m, a student hangs the cord from a rod as represented above and then attaches a variety of weights to the cord. For each weight, the student allows the weight to hang in equilibrium and then measures the entire length of the cord. The data are recorded in the table below:

Weight (N)	0	10	15	20	25
Length (m)	0.60	0.97	1.24	1.37	1.64

(a) Use the data to plot a graph of weight versus length on the axes below. Sketch a best-fit straight line through the data.



(b) Use the best-fit line you sketched in part (a) to determine an experimental value for the spring constant k of the cord.

$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta \text{Force}}{\Delta x} = k$

$k = \frac{25-10}{1.6-1} = \frac{15}{.6} = 25\ \text{N/m}$