2014

NAME: KEY

Assessment: *Oscillations*

Multiple Choice: *Choose the letter of the best answer. 3 points each.*

1. A — A 5 kg mass on a spring has a natural frequency of 0.35 Hz. What is the spring constant of the spring?
   a. 24.2 N/m. b. 40.1 N/m. c. 64.5 N/m. d. 202.5 N/m. e. 1610 N/m.

2. C — A 2 meter long thin rod is hanging from one of its end points and is oscillating. What is its period of oscillation?
   a. 7.9 s. b. 3.4 s. c. 2.3 s. d. 1.6 s. e. None of those.

3. E — A simple 1 meter long pendulum is oscillating in an elevator that is accelerating down at 3 m/s^2. What is its period of motion?
   a. 0.28 s. b. 0.38 s. c. 1.74 s. d. 1.99 s. e. 2.37 s.

Questions 4 to 6 refer to the following:
The velocityπ of a 75 gram mass on a spring is given by the equation $\dot{x} = \pi \sin(4t)$

4. B — What is the maximum displacement of the mass?
   a. π. b. π/4. c. 4π. d. 2π. e. 2.

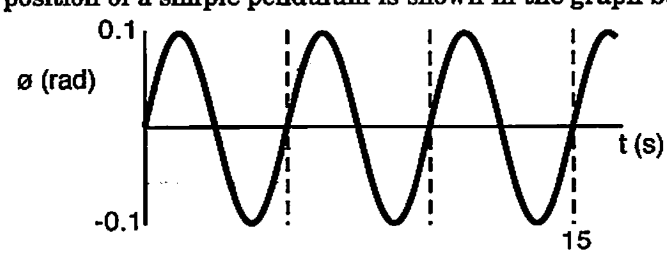
5. D — Which of the following functions would best represent its acceleration?
   a. $-\pi\sin(4t)$ b. $\pi\cos(4t)$ c. $-16\pi\sin(4t)$ d. $4\pi\cos(4t)$ e. $-4\pi\cos(4t)$

6. B — What is the frequency of the motion?
   a. 1/π Hz. b. 2/π Hz. c. 4/π Hz. d. 1/(2π) Hz. e. 1/(4π) Hz.

7. A — If you wanted to double the period of a simple pendulum, what single thing could you do?
   a. quadruple its length. b. divide its length by 4.
   c. quadruple its mass. d. divide its mass by 4.
   e. More than one of those answers is correct.

8. E — What is the period of motion for a 2 kg mass attached to a 100 N/m spring on a frictionless incline with a base angle of 30°?
   a. 0.44 s. b. 0.77 s. c. 0.13 s. d. 0.94 s. e. 0.89 s.

Questions 9 and 10 refer to the following:
The angular position of a simple pendulum is shown in the graph below.



9. D — What is the length of the pendulum?
   a. 4.46 m. b. 57 m. c. 0.10 m. d. 6.33 m. e. 3.98 m.

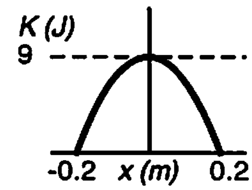
10. C — What is the angular frequency of the pendulum?
   a. 0.13 rad/s. b. 0.16 rad/s. c. 1.26 rad/s. d. 6.28 rad/s. e. None of those.

11. C — What has to be true for an object to undergo simple harmonic motion?
   a. It has to be attached to a spring.
   b. Its total energy must be constant.
   c. Its acceleration must be directly proportional to its position.
   d. There must be a source of potential energy.

NAME: ______________

Assessment: *Oscillations*

12. B The kinetic energy as a function of position for a mass on a spring is given by the graph shown to the right. What is the spring constant?
a. 18 N/m. b. 450 N/m. c. 0.18 N/m. d. 45 N/m.
e. Need the mass to answer the question.



13. A What is the equation of motion for a mass m attached to a spring with a spring constant of k that is somehow experiencing a damping force that is always proportional (by a constant b) to its velocity?
a. $m\ddot{x}+b\dot{x}+kx=0$ b. $m\ddot{x}-b\dot{x}-kx=0$
c. $\ddot{x}=b\dot{x}+kx$ d. $m\ddot{x}=-(k+b)x$
e. Huh? Sadly, I have no idea what you are talking about so mark me wrong.

14 @ 3 = 42
6
20
24
92

14. D The amplitude of oscillation of a simple pendulum is increased from 1° to 4°. It's maximum acceleration changes by a factor of
a. 1/4. b. 1/2. c. 2. d. 4. e. 16.

Problem Solving: Show all work.

(6) 15. What is meant by the term *resonance*?

Forced osc.
Natural f
Big Amplitude

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

$\omega=\sqrt{\frac{k}{m}}$

$\omega=\sqrt{\frac{k}{m}}$

$\pi=\sqrt{\frac{k}{2}}$ → $k=2\pi^2=19.7$

$U=\frac{1}{2}kx^2=\frac{1}{2}(2\pi)^2(6)^2=36\pi^2=$

(10) 16. The position as a function of time for an oscillating mass (2 kg) on a spring is given by x = 6 cos (πt), where t is in seconds and x is in meters. What is the total energy of the mass-spring system? → either $\frac{1}{2}mv^2$ or $\frac{1}{2}kx^2$

~~A = 6~~

K+U -3

$\therefore V = 6\pi\sin(\pi t)$

$V_{max}=6\pi$ → $\frac{1}{2}(2)(6\pi)^2 = 36\pi^2 = \boxed{355\ J}$

B $\boxed{\frac{1}{2}(3)(6\pi)^2 = 53...}$

(10) 17. A 3 kg mass is suspended from a spring, stretching the spring a distance of 35 cm. It is then pulled down an additional 15 cm. What is its maximum speed?

kx
mg

$(3)(10)=k(.35)$

$k=\frac{30}{.35}=\underline{85.7}\ N/m$

$\Rightarrow \therefore \omega=\sqrt{\frac{k}{m}}=\sqrt{\frac{85.7}{3}}$

$\omega = \underline{5.35}$

wrong x to find k -3

$\frac{1}{2}kx^2 = mgh$ -5

$k=\frac{mg}{x}$

$\omega=\sqrt{\frac{mg/x}{m}}=\sqrt{\frac{g}{x}}$

$A\sqrt{\frac{g}{x}}$

Then $A = .15$

$V_{max} = A\omega = (.15)(5.35) = \boxed{.80\ m/s}$

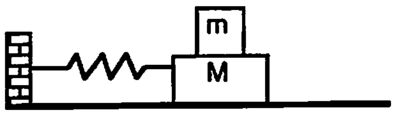
a

$\left[\text{or } \frac{1}{2}(85.7)(.15)^2=\frac{1}{2}(3)v^2\right] \Rightarrow E = .96J$

Assessment: *Oscillations*

(12)

18. A 2 kg mass is on top of a 3 kg mass, which is on a frictionless table. The 3 kg mass is attached to a spring of constant 60 N/m. The 2 kg mass always stays on top of the 3 kg mass without sliding, and the maximum speed the masses ever have is 2.3 m/s. What is the minimum coefficient of friction between the blocks?



on top $f \leftarrow$

$f = ma$

$\mu m g = ma$

$\mu = \frac{a}{g}$

$\omega = \sqrt{\frac{k}{m}}$; $\omega = \sqrt{\frac{60}{5}} = \sqrt{12}$

$\omega = 3.46$

$k = 60$ N/m

$M = 2+3 = \cancel{4}5$ kg

$k = 70$

$M = 6$

$\omega = \sqrt{\frac{70}{6}} = 3.42$

$x = .673$

$a = 7.86$

$\mu = .786$

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$ (max KE)

$\frac{1}{2}(5)(2.3)^2 = \frac{1}{2}(60)x^2$

$x^2 = 0.44$

$\underline{x = .664}$ (= max amplitude)

$KX = Ma$

$(60)(.664) = 5a$

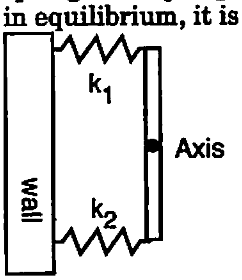
$\underline{a = 7.97 \text{ m/s}^2}$

$\therefore \boxed{\mu = \frac{7.97}{10} = .797}$

just bottom mass $kx = ma$ −3

(12)

19. A thin rod of mass M and length L is rotating about its center of mass. At each end, there is a spring with spring constants as shown. The springs are attached to a wall. When the system is in equilibrium, it is vertical, as shown. What is the period of small oscillations?



$\Sigma \tau = I\alpha$

$\tau_1 + \tau_2 = -\frac{1}{12}ML^2\alpha$

$\tau_1 = \frac{L}{2}k_1 x$

$\tau_2 = \frac{L}{2}k_2 x$

$\xi \; x \approx \frac{L}{2}\theta$

$\therefore \frac{L}{2}K_1\left(\frac{L}{2}\theta\right) + \frac{L}{2}k_2\left(\frac{L}{2}\theta\right) = -\frac{1}{12}ML^2\ddot{\theta}$

$\frac{1}{\cancel{4}}\cancel{L^2}K_1\theta + \frac{1}{\cancel{4}}\cancel{L^2}k_2\theta = -\frac{1}{\cancel{12}}M\cancel{L^2}\ddot{\theta}$

$(K_1 + K_2)\theta = -\frac{1}{3}M\ddot{\theta}$

$\ddot{\theta} = -\frac{3(K_1+K_2)}{M}\theta$

$\therefore \boxed{T = 2\pi\sqrt{\frac{M}{3(K_1+K_2)}}}$

wrong I −2

(2) cancelling out $\ddot{\theta}$ −3