

Your name: \_\_\_\_\_

Total 14 problems, 7 pages. No separate solution sheets necessary.

Good luck!

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For the following ten problems, you can indicate your answer by drawing a circle around one of the choices. The best choice is unique for each problem. No explanation necessary. Each of the following ten problems is worth 1 point.

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**Problem 1** In a grandfather clock, the pendulum measures the time elapsed. A grandfather clock is gaining time. Should you shorten or lengthen the pendulum?

- (a) shorten it
- (b) lengthen it
- (c) do neither (will make no difference)

**Problem 2** A simple harmonic motion is always sinusoidal.

- (a) True
- (b) False

**Problem 3** A student designs a clock using a mass and a spring. Each oscillation of the mass advances the clock by one second. When the student builds the clock, he discovers he erred and each oscillation takes two seconds. What change can he make to fix the clock?

- (a) double the amplitude of the oscillations
- (b) quadruple the spring constant of the spring
- (c) double the spring constant of the spring
- (d) quadruple the mass
- (e) double the mass

**Problem 4** A mass  $M$  is attached to a spring with spring constant  $k$ . When this system is set in motion with amplitude  $A$ , it has a period  $T$ . What is the period if the amplitude of the motion is increased to  $2A$ ?

- (a)  $2T$
- (b)  $T/2$
- (c)  $\sqrt{2}T$
- (d)  $4T$
- (e)  $T$

**Problem 5** A mass on a spring undergoes SHM. When the mass is at its maximum displacement from equilibrium, its instantaneous velocity

- (a) is maximum.

- (b) is less than maximum, but not zero.
- (c) is zero.
- (d) cannot be determined without mass information given.
- (e) cannot be determined without spring constant information given.

**Problem 6** What is impossible about the following situation? An object in simple harmonic motion has an equilibrium position  $x = 0.00$  m. At some instant in time, the position of the object is  $+3.00$  m, the velocity is  $-2.00$  m/s, and the acceleration is  $+9.00$  m/s<sup>2</sup>.

- (a) The numerical value of the velocity is smaller than the distance from the equilibrium position, but the numerical value of the magnitude of the acceleration is larger than the distance from equilibrium.
- (b) The velocity is opposite in direction to the displacement.
- (c) The acceleration is greater than the speed.
- (d) The speed is less than the displacement.
- (e) The displacement from equilibrium and the acceleration are in the same direction.

**Problem 7** A vertical spring has a mass hanging from it, which is displaced from the equilibrium position and begins to oscillate. At what point does the system have the least potential energy?

- (a) at the highest point
- (b) at one-fourth of the distance between the highest point and lowest point
- (c) at the lowest point
- (d) at the point where the spring is un-stretched
- (e) at the equilibrium point

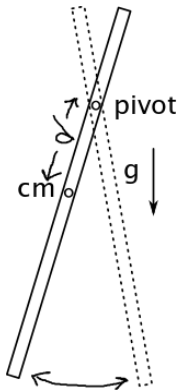
**Problem 8** A nail is stuck into the side of a car tire. As the car drives down a level road at constant speed, which of the following is simple harmonic motion, when observed in the rest frame outside the car?

- (a) the motion of the center of the tire
- (b) the vertical component of motion of the nail
- (c) the horizontal component of motion of the nail
- (d) both answers b and c
- (e) none of the above



**Problem 11** A thin rod of total length  $l$ , uniform density, and total mass  $m$ , is used as a physical pendulum. Its pivot point is at distance  $d$  from its center of mass. Find the period  $T$  as a function of  $d$ , and other parameters given.  $T$  has an extremum value as  $d$  changes from 0 to  $l/2$ . Find that extremum value of  $T$ , the nature of it (minimum or maximum), and the corresponding value of  $d$ . [Hint: the moment of inertia of thin uniform rod around the center of mass:  $I_{cm} = ml^2/12$ .]

*Your solution:*



**Problem 12** Consider a mass on spring system, with mass  $m$  and  $k$ . Let  $A$  be the amplitude and  $v_{max}$  be the maximum speed. Find the values of displacement  $x$  and velocity  $v = \dot{x}$  in terms of these parameters, when the kinetic energy is twice the potential energy.

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*Your solution:*

**Problem 13** Traveling waves are created on a rope that has a mass per length 0.200 kg/m that is stretched with a tension of 400 N. If the end of the rope is moved up and down with simple harmonic motion with amplitude 30.0 cm and a period 1.40 s, how much work is done in one period of the motion?

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*Your solution:*

**Problem 14** The mass density of platinum is  $21.4 \times 10^3 \text{ kg/m}^3$ . A platinum wire with a radius of 0.500 mm, 1.20 m long, fixed at both ends has a frequency of vibration for its third harmonic (i.e., the third lowest frequency possible) equal to 512 Hz. What is the tension in the wire?

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*Your solution:*