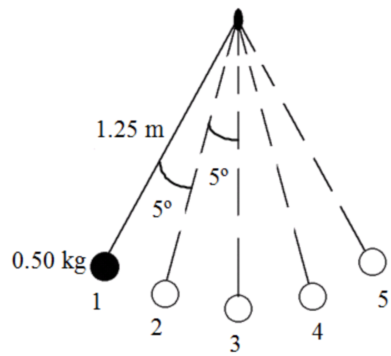
AP Physics 1
Unit 7 Practice Exercises

7.1 – Pendulums

1. A simple pendulum on earth has a period of 6.0 s. What is the approximate period of this pendulum on the moon where the acceleration due to gravity is roughly 1/6 that of earth?

2. A simple pendulum has a length of 52.0 cm and makes 82.0 complete oscillations in 2.00 min. Find (a) the period of the pendulum and (b) the value of g at the location of the pendulum

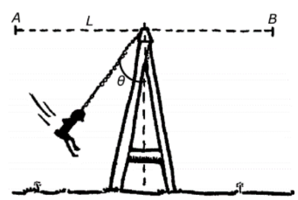
3. As shown in the figure, a 0.50 kg bob swinging at the end of a string with negligible mass undergoes simple harmonic motion. Various positions along the bob's arc are labeled 1 thru 5. Point 3 is the lowest point of the swing and points 1 and 5 represent the bob's maximum displacement from the vertical.

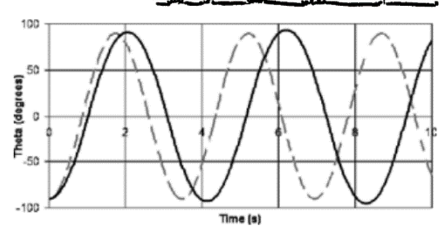


a) Between what two points does the bob gain the most speed?
b) How long does it take the pendulum to swing from point 1 to point 5?
c) What is the speed of the pendulum at point 3?
d) What is the tension in the string at point 3?
e) What is the tension in the spring at point 5?
f) Describe one modification you could make to double the period of oscillation.

4. Donkey Kong swings from a 50 m long rope. He started at angle of 20° with the vertical.
a) Determine the time required for Donkey Kong to reach equilibrium.
b) Determine Donkey Kong's speed at equilibrium.
c) At the equilibrium point, Donkey Kong strikes a boulder and becomes stuck to the boulder in classic cartoon fashion. If Donkey Kong has a mass of 140 kg and the boulder has a mass of 500 kg, what is the speed of the boulder after the collision?
d) Diddy Kong was pushed back 5 m in stopping the boulder. What was the average force applied by Diddy Kong?

5. A 20-kg child swings on a swing set. The chains supporting the swing are L = 3 m long. At time t = 0, the child is at point A, where the angular displacement of the chains supporting the swing is θ = −90°. The child swings between points A and B, that is between the angular displacements of −90° and +90°. Angela uses video analysis to measure the angular displacement of the chains.

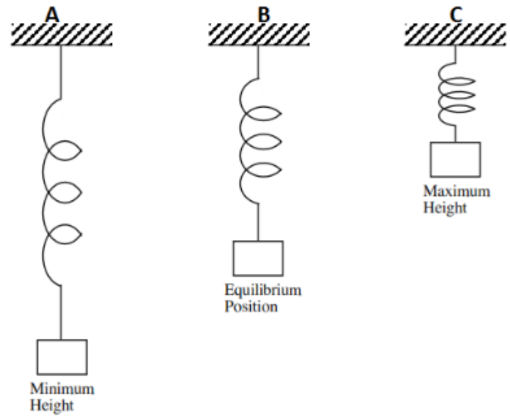




a) The dashed line on the above left graph shows the angular displacement of the chains if the swing is modeled as a simple pendulum swinging with simple harmonic motion. The dashed (SHM model) and solid (collected data) lines are not aligned. Explain why this is the case.
b) Angela suggests that the tension in the chains is 200 N when the child swings through θ = 0°. She reasons that this is because the child is neither speeding up nor slowing down, so the tension must balance the weight force according to Newton's second law.
i. What aspects of Angela's claim and reasoning are correct? Explain.
ii. What aspects of Angela's claim and reasoning are incorrect? Explain.
iii. Explain why the tension in the chains is greater than 200 N when θ = 0°.

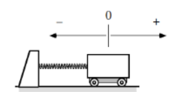
7.2 – Springs

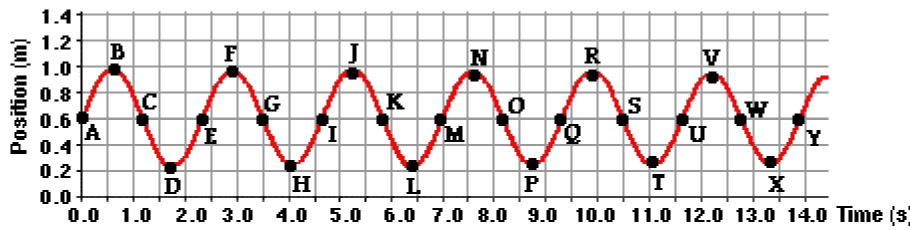
1. A weight attached to a spring is released from position A, as shown. It moves up and down in simple harmonic motion.



a) When is the speed of the weight at its maximum?
b) When is the speed of the weight at its minimum?
c) When is the weight's acceleration zero?
d) At which point is the acceleration at its maximum magnitude?
e) As the weight goes from A to B, how is the direction of the velocity of the mass related to its acceleration?
f) The amplitude is the distance from point A to which point?
g) Describe the motion of the mass from point A to complete one period.
h) In one period, the weight travels a distance equal to how many amplitudes?
i) If it takes 2.1 s for the mass to move from A to B, what is the period of the system?

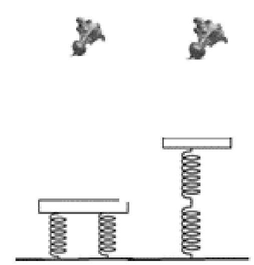
2. A cart attached to a spring is displaced from equilibrium and then released. There is no friction. A graph of displacement as a function of time for the cart is shown. The arrows and signs above the cart indicate the positive and negative directions for the position of the cart.





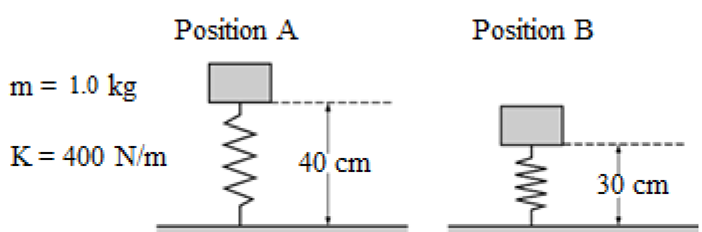
a) What is the frequency of the mass's motion?
b) What is the amplitude of the mass's motion?
c) At what points is potential energy of the cart a maximum?
d) Write an equation for the position of the mass as a function of time.

3. Dr. Dre drops a dope beat of mass m = 2.0 from a a height of h = 10 m above a spring. The beat lands on two identical springs. The two springs (each of k = 100 N/m) can be arranged in series or parallel, as shown.



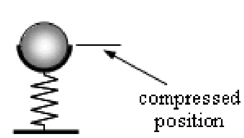
a) In which arrangement will the spring oscillate with a greater period?
b) Using your arrangement from a), calculate:
i. The max distance the springs compress from their initial position.
ii. The frequency of oscillation.

4. A person holds a 1.0 kg block at position A shown on the left, in contact with an uncompressed vertical spring with a spring constant of 400 N/m. The person gently lowers the block from rest at position A to rest at position B.



a) Calculate the change in energy between positions A and B.
b) Does the person do positive or negative work on the block? How can you tell?

5. A ping-pong ball weighs 0.025 N. The ball is placed inside a cup that sits on top of a vertical spring. The spring is compressed 0.055 m and released, the maximum height above the compressed position that the ball reaches is 2.84 m.



a) Determine the value of the spring constant.
b) Calculate the maximum speed of the ball.

6. A 20 kg box on a horizontal frictionless surface is moving to the right at a speed of 4.0 m s. The box hits and remains attached to one end of a spring of negligible mass whose other end is attached to a wall. As a result, the spring compresses a maximum distance of 0.50 m, and the box then oscillates back and forth.

a) Calculate the value of the spring constant.

b) Calculate the magnitude of the maximum acceleration of the box.

c) Calculate the frequency of oscillation of the spring.

7. In an experiment to calculate the spring constant of a spring, a spring is attached to a mass of 2 kg. When the mass is hung vertically from the spring, the spring stretches 20 cm.

In a separate experiment, the spring is attached horizontally on the ground to the same mass and compressed to the right with a force of 50 N and allowed to oscillate.

a) Determine a mathematical expression for x(t), the position of the spring vs. time in the second experiment. Show your work.

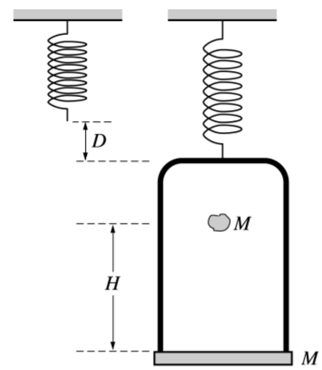
b) Sketch the position, velocity, and acceleration vs. time for the spring for one period. Ensure the axes are labeled.

8. An ideal spring is hung from the ceiling and a pan of mass M is suspended from the end of the spring, stretching it a distance D as shown. Anakin drops a lump of sand, also of mass M, from a height H onto the pan. The sand sticks to the pan.

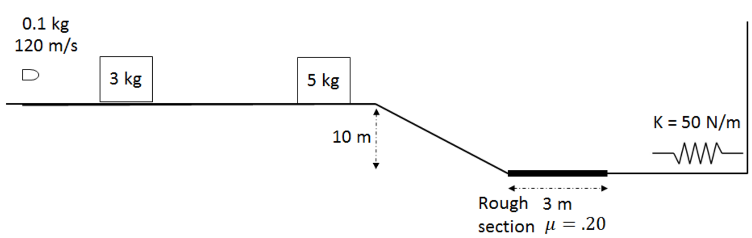
a) Determine the speed of the pan just after the sand strikes.

b) Determine the period of the simple harmonic motion that ensues.

c) The clay is now removed from the pan and the pan is returned to equilibrium at the end of the spring. A bouncing ball, also of mass M is dropped from the same height H onto the pan. Would the period of the resulting simple harmonic motion be greater than, less than, or equal to the answer from part b)?



9. Oh no. A bullet of mass 0.1 kg is fired to the right at a 120 m/s as shown. The bullet collides and becomes embedded in a 3 kg block. The bullet/block then slide to the right and bounce off a 5 kg block. After the collision, the 3 kg block moves the left at 1 m/s. The 5 kg block then slides down a smooth incline that is 10 m tall. At the bottom of the incline, it travels through a 3 m long stretch of horizontal surface with friction equal to $\mu = 0.3$. The block then continues on another frictionless surface before hitting and rebounding off a spring with elastic constant k = 50 N/m. The block rebounds off the spring at the same speed it hit the spring at.



a) Calculate the speed of the bullet/3kg block combo after they collide.

b) Calculate the speed of the 5 kg block after colliding with the 3 kg block.

c) Calculate the speed of the 5 kg block after reaching the bottom of the incline.

d) Calculate the speed of the 5 kg block after sliding across the rough portion.

e) Calculate the maximum distance the spring is compressed from its equilibrium position.

f) Does the spring do net work on the block? Justify your answer.

g) Is the momentum of the block conserved when hitting the spring? Justify your answer.

h) Did you enjoy this problem?