Simple Harmonic Motion Chapter Problems

Period, Frequency and Velocity:

Class Work

1. A mass-spring system makes 20 complete oscillations in 5 seconds. What is the period and frequency of the oscillations?

2. A mass-spring system oscillates with a period of 6 seconds. How long will it take to complete 8 complete cycles?

3. A simple pendulum oscillates with a period of 5 seconds. How many complete oscillations does it make in 15 seconds?

4. A simple pendulum oscillates with a frequency of 25 Hz. What is the period?

5. A simple pendulum oscillates with a period of 4 s. What is the frequency?

Homework

6. A mass-spring system makes 50 complete oscillations in 10 seconds. What is the period and frequency of the oscillations?

7. A mass-spring system oscillates with a frequency of 20 Hz. What is the period?

8. A simple pendulum oscillates with a period of 2 seconds. How many complete oscillations does it make in 30 seconds?

9. A simple pendulum oscillates with a period of 7 seconds. How long will it take to complete 15 complete cycles?

10. A mass-spring system oscillates with a period of 0.5 s. What is the frequency?

Force Exerted by a Spring:

Class Work

11. What is the mass which causes a spring of k = 80 N/m to stretch by 4 cm?

12. A spring stretches 5 cm when a 1 kg mass is suspended from it. What is the spring constant?

Homework

13. What is the mass which causes a spring of k = 100 N/m to stretch by 10 cm?

14. A spring stretches 7 cm when a 1.2 kg mass is suspended from it. What is the spring constant?

Energy of a Mass-Spring System:

Class Work

15. A mass of 1.4 kg is attached to a horizontal spring with a spring constant of 75 N/m. The spring is stretched from equilibrium position by 5 cm and released.
    a. What is the maximum elastic potential energy?
    b. What is the maximum kinetic energy?
    c. What is the maximum speed of the mass?
    d. At which point the maximum speed will be reached?
16. A mass of 2.7 kg is attached to a horizontal spring with a spring constant of 96 N/m. The spring is stretched from equilibrium position by 7 cm and released.
    a. What is the maximum elastic potential energy?
    b. What is the maximum kinetic energy?
    c. What is the maximum speed of the mass?
    d. At which point the maximum speed will be reached?

Homework

17. A mass of 3.6 kg oscillate on a horizontal spring with a spring constant of 160 N/m. When the mass passes the equilibrium point its speed is 5.2 m/s.
    a. What is the maximum kinetic energy?
    b. What is the total energy?
    c. What is the maximum elastic potential energy?
    d. What is the maximum displacement of the mass?
    e. Make a sketch of a mass-spring oscillating system and show maximum displacement, equilibrium point and the energies related to these points.

18. A mass of 1.8 kg oscillate on a horizontal spring with a spring constant of 120 N/m. When the mass passes the equilibrium point its speed is 4.8 m/s.

    a. What is the maximum kinetic energy?

    b. What is the total energy?

    c. What is the maximum elastic potential energy?

    d. What is the maximum displacement of the mass?

    e. Make a sketch of a mass-spring oscillating system and show maximum displacement, equilibrium point and the energies related to these points.

Period and Frequency of a Mass-Spring System:

Class Work

19. What is the period of a mass-spring oscillation system with a spring constant of 120 N/m and mass of 0.5 kg?

20. What is the spring constant of a mass-spring oscillating system making 10 complete oscillations in 5 seconds when a mass of 2 kg is suspended from the spring?

21. What is the mass suspended from a spring of 200 N/m making 20 complete cycles in 50 seconds?

22. What is the frequency of a mass-spring oscillation system with a spring constant of 125 N/m and mass of 3 kg?

Homework

23. What is the period of a mass-spring oscillation system with a spring constant of 250 N/m and mass of 5 kg?

24. What is the spring constant of a mass-spring oscillating system making 15 complete oscillations in 30 seconds when a mass of 0.2 kg is suspended from the spring?

25. What is the mass suspended from a spring of 150 N/m making 10 complete cycles in 30 seconds?

26. What is the frequency of a mass-spring oscillation system with a spring constant of 210 N/m and mass of 7 kg?

Period and Frequency of a Simple Pendulum:

Class Work

27. A simple pendulum with a length of 2 m oscillates on the Earth's surface. What is the period of oscillations?

28. What is the length of a simple pendulum oscillating on Earth with a period of 0.5 s?

29. A 2.2 m long simple pendulum oscillates with a period of 4.8 s on the surface of unknown planet. What is the surface gravity of the planet?

30. A simple pendulum with a length of 2.6 m oscillates on the Earth's surface. What is the frequency of oscillations?

Homework

31. A simple pendulum with a length of 1 m oscillates on the Moon's surface where acceleration due to gravity is $1.7 m/s^2$. What is the period of oscillations?

32. What is the length of a simple pendulum oscillating on Earth with a period of 1.2 s?

33. A 3.4 m long simple pendulum oscillates with a period of 2.4 s on the surface of unknown planet. What is the surface gravity of the planet?

34. A simple pendulum with a length of 1.8 m oscillates on the Moon's surface where acceleration due to gravity is $1.7 m/s^2$. What is the frequency of oscillations?

Energy in a Pendulum

Classwork

35. A mass of 0.5 kg oscillates on a simple pendulum with a length of 1.5 m that reaches a maximum height of 0.08 m when it is in SHM.
    a. What is the maximum gravitational potential energy?
    b. What is the maximum kinetic energy?
    c. What is the total energy of the system?
    d. What is the maximum speed of the mass?
    e. At which point the maximum speed is reached?

36. A mass of 0.6 kg oscillates on a simple pendulum with a length of 0.9 m that reaches a maximum height of 0.04 m when it is in SHM.

    a. What is the maximum gravitational potential energy?

    b. What is the maximum kinetic energy?

    c. What is the total energy of the system?

    d. What is the maximum speed of the mass?

    e. At which point the maximum speed is reached?

Homework

37. A mass of 0.6 kg oscillates at the end of a 2 m long string. When the mass passes the lowest point its speed is 0.9 m/s.
    a. What is the maximum kinetic energy of the system?

    b. What is the maximum gravitational potential energy of the system?

    c. What is the total energy of the system?

    d. What is the maximum height the mass reaches during SHM?

    e. Make a sketch of the simple pendulum and show the maximum displacement, equilibrium point and energies related to these points.

38. A mass of 0.8 kg oscillates at the end of a 1.9 m long string. When the mass passes the lowest point its speed is 0.7 m/s.

    a. What is the maximum kinetic energy of the system?

    b. What is the maximum gravitational potential energy of the system?

    c. What is the total energy of the system?

    d. What is the maximum height the mass reaches during SHM?

    e. Make a sketch of the simple pendulum and show the maximum displacement, equilibrium point and energies related to these points

Simple Harmonic Motion

General Problems

1. A bullet m = 0.001 kg moves with a speed of 500 m/s and strikes a block M = 2 kg at rest. After the collision the bullet becomes embedded into the block. The block is attached to the end of a spring k = 120 N/m.

    a. What is the initial kinetic energy of the bullet?

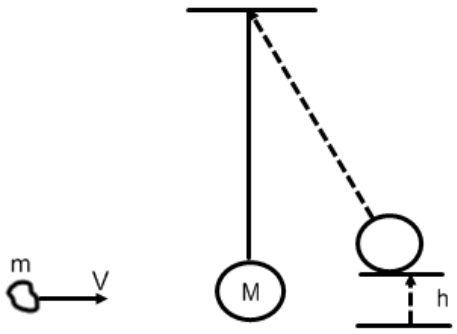
    b. What is the speed of the bullet-block system after the collision?

    c. What is the kinetic energy of the bullet-block system after the collision?

    d. What is the maximum elastic potential energy when the block comes to rest?

    e. What is the maximum compression of the spring?

    f. What is the period of oscillations?



2. A piece of clay m = 0.04 kg has a speed of 15 m/s as shown above. The clay strikes a pendulum bob M = 0.5 kg and sticks to it. The pendulum bob is attached to a string that is 0.5 meters long. As a result of the collision the pendulum swings to the right and the bob moves up by distance h.

   a. What is the initial kinetic energy of the clay?

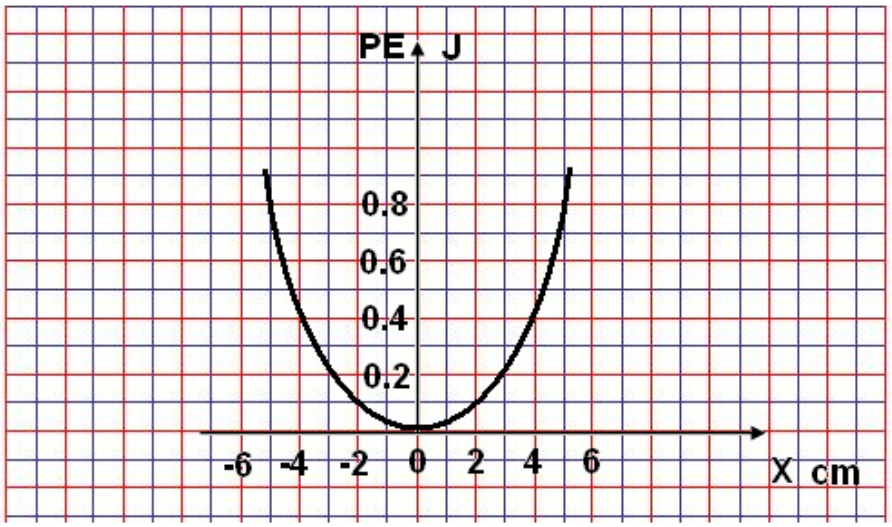
   b. What is the speed of the clay-bob system after the collision?

   c. What is the kinetic energy of the clay-bob system after the collision?

   d. What is the maximum gravitational potential energy of the clay-bob system?

   e. Find the maximum height of the bob after the collision.

   f. What is the period of oscillations?



3. A 0.5 mass is attached to a horizontal spring which undergoes SHM. The graph of EPE as a function of position show above. The total energy of the oscillating system is 0.8 J.

    a. Draw the graph of total energy as a function of position.

    b. Draw the graph of kinetic energy as a function of position.

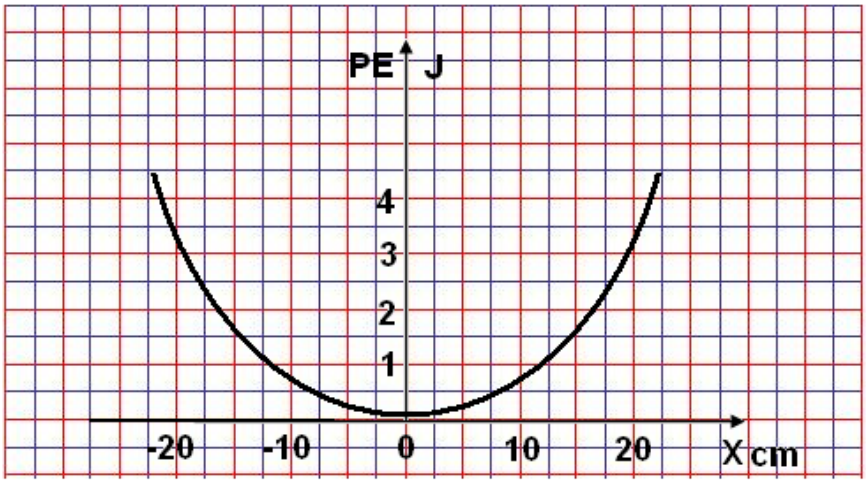
    c. What is the maximum displacement of the oscillating mass?

    d. What is the potential energy at the position of 2 cm?

    e. What is the kinetic energy at the position of 2 cm?

    f. Find the location of the oscillating mass when its potential energy is 0.7 J.

    g. What is the period of oscillations?



4. A 0.6 mass is attached to a horizontal spring which undergoes SHM. The graph of EPE as a function of position show above. The total energy of the oscillating system is 3 J.

    a. Draw the graph of total energy as a function of position.

    b. Draw the graph of kinetic energy as a function of position.

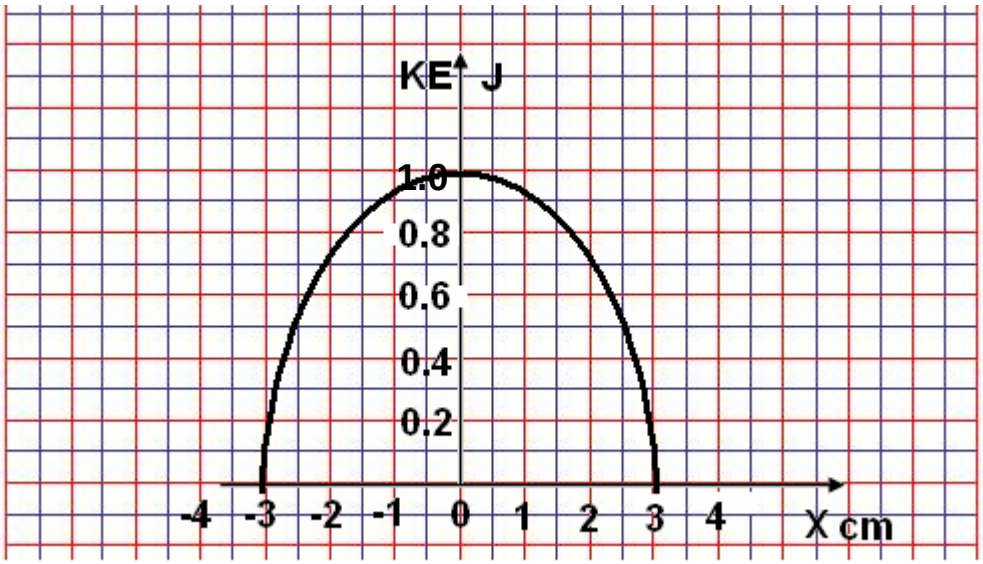
    c. What is the maximum displacement of the oscillating mass?

    d. What is the potential energy at the position of 7.5 cm?

    e. What is the kinetic energy at the position of 7.5 cm?

    f. Find the location of the oscillating mass when its potential energy is 1.5 J.

    g. What is the period of oscillations?



5. A 0.4 mass is attached to a horizontal spring which undergoes SHM. The graph of KE as a function of position show above.

    a. Draw the graph of total energy as a function of position.

    b. Draw the graph of potential energy as a function of position.

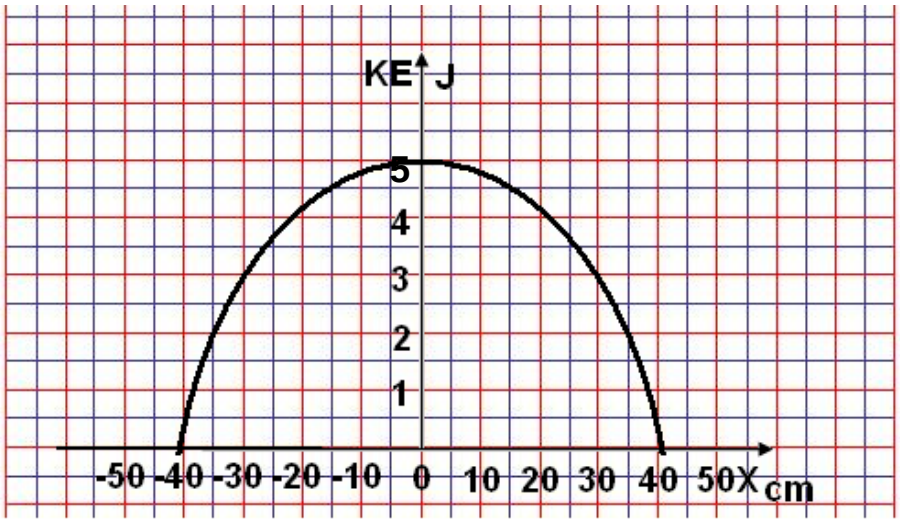
    c. What is the maximum displacement of the oscillating mass?

    d. What is the potential energy at the position of 2 cm?

    e. What is the kinetic energy at the position of 2 cm?

    f. Find the location of the oscillating mass when its kinetic energy is 0.5 J.

    g. What is the period of oscillations?



6. A 0.8 mass is attached to a horizontal spring which undergoes SHM. The graph of KE as a function of position show above.

    a. Draw the graph of total energy as a function of position.

    b. Draw the graph of potential energy as a function of position.

    c. What is the maximum displacement of the oscillating mass?

    d. What is the potential energy at the position of 20 cm?

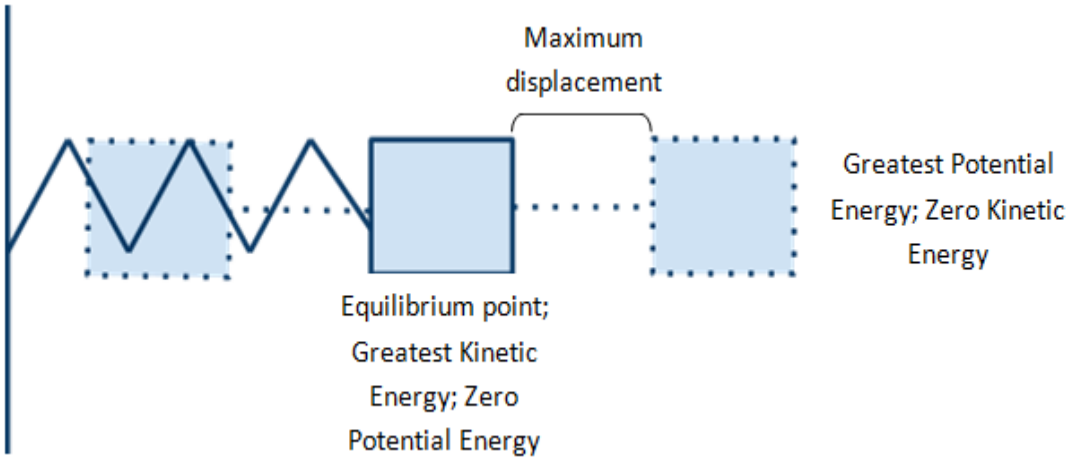
    e. What is the kinetic energy at the position of 20 cm?

    f. Find the location of the oscillating mass when its kinetic energy is 2 J.

    g. What is the period of oscillations?

Answers

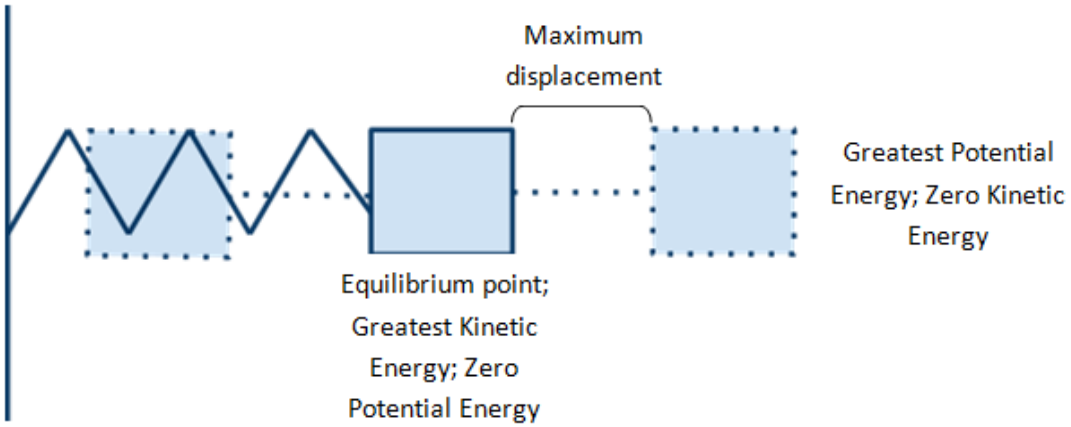
1. T = 0.25 s ; f = 4 Hz
2. 48 s
3. 3
4. 0.04 s
5. 0.25 Hz
6. T = 0.2 s ; f = 5 Hz
7. 0.05 s
8. 15
9. 105 s
10. 2 Hz
11. 0.32 kg
12. 196 N/m
13. 1 kg
14. 168 N/m
15.
    a. 0.0938 J
    b. 0.0939 J
    c. 0.366 m/s
    d. x = 0 m (when there is no displacement)
16.
    a. 0.2352 J
    b. 0.2352 J
    c. 0.417 m/s
    d. x = 0 m (when there is no displacement)
17.
    a. 48.672 J
    b. 48.672 J
    c. 48.672 J
    d. x = 0.78 m



e.

18.

a. 20.736 J
b. 20.736 J
c. 20.736 J
d. 0.588 m

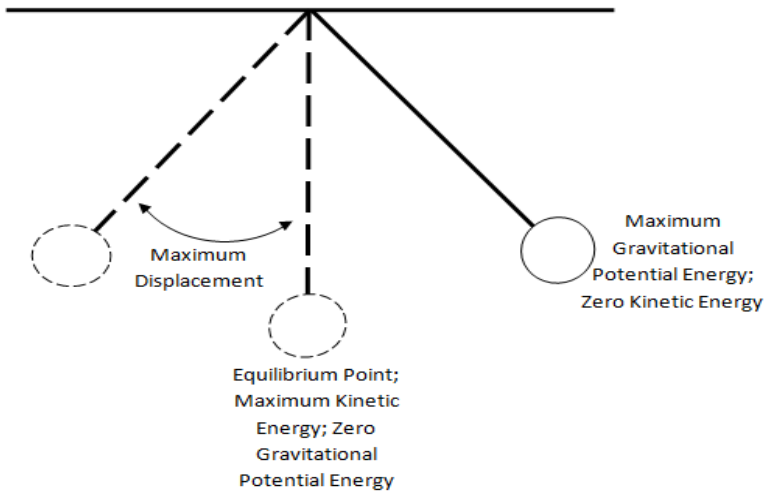


e.

19. 0.405 s
20. 315.827 N/m
21. 31.66 kg
22. 1.02 Hz
23. 0.889 s
24. 1.974 N/m
25. 34.2 kg
26. 0.87 Hz

27. 2.84 s
28. 0.06 m
29. 3.77 m/s^2
30. 0.309 Hz
31. 4.82 s
32. 0.357 m
33. 23.3 m/s^2
34. 0.154 Hz
35.
    a. 0.392 J
    b. 0.392 J
    c. 0.392 J
    d. 1.252 m/s
    e. x = 0 m (when there is no displacement)
36.
    a. 0.2352 J
    b. 0.2352 J
    c. 0.2352 J
    d. 0.885 m/s
    e. x = 0 m (when there is no displacement)

37.
    a. 0.243 J
    b. 0.243 J
    c. 0.243 J
    d. .04 m
    e.



38.

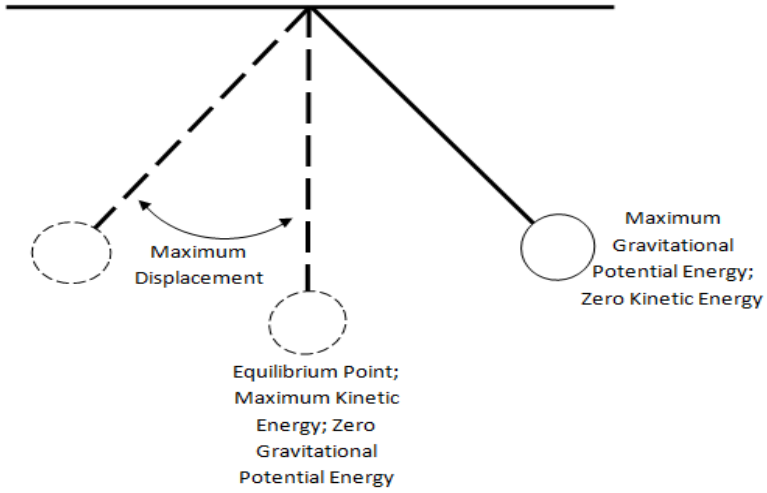
a. 0.196 J

b. 0.196 J

c. 0.196 J

d. 0.025 m

e.

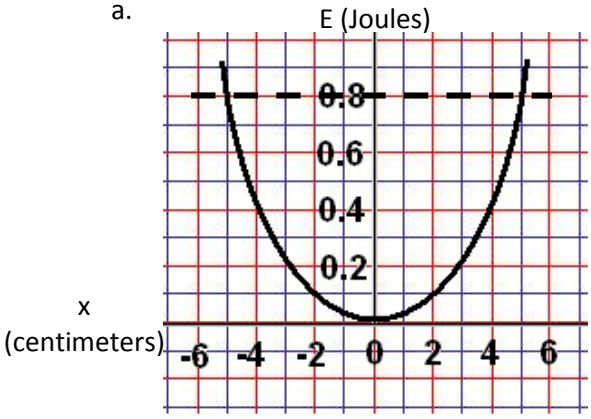


Simple Harmonic Motion: General Problems

1.
   a. 125 J
   b. 0.25 m/s
   c. 0.0625 J
   d. 0.0625 J
   e. 0.032 m
   f. 0.81 s

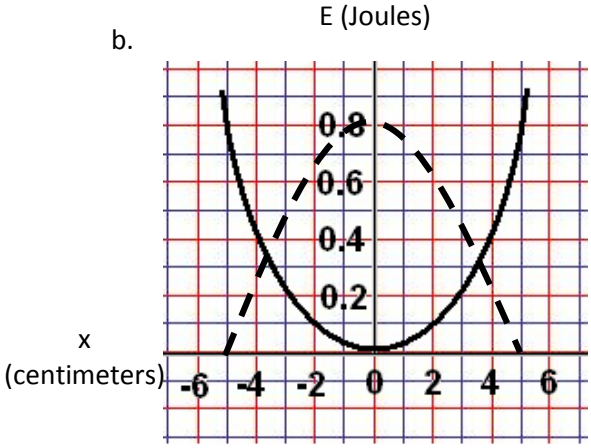
2.
   a. 4.5 J
   b. 1.111 m/s
   c. 0.33 J
   d. 0.33 J
   e. 0.062 m
   f. 1.42 s

3.
   a.



Total Energy is a straight line (dashed) at 0.8 J.

   b.

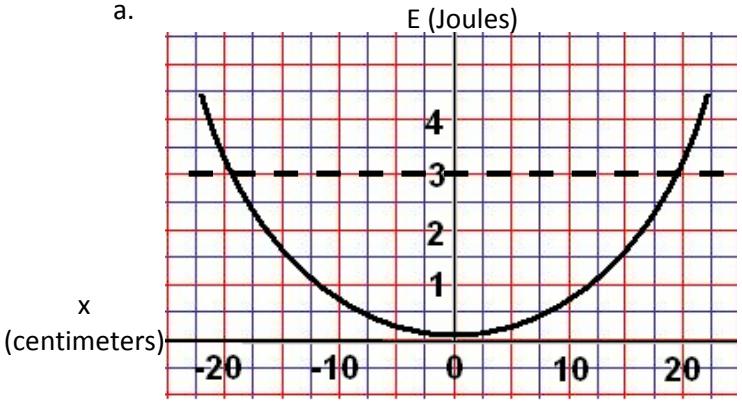


Kinetic Energy is a negative parabola (dashed) that intersects the y-axis at 0.8 J and the x-axis at -5 cm and 5 cm.

c. 0.05 m
d. 0.128 J (0.01 J)
e. 0.672 J (0.7 J)
f. 4.68 cm (4.5 cm)
g. 0.1756 s

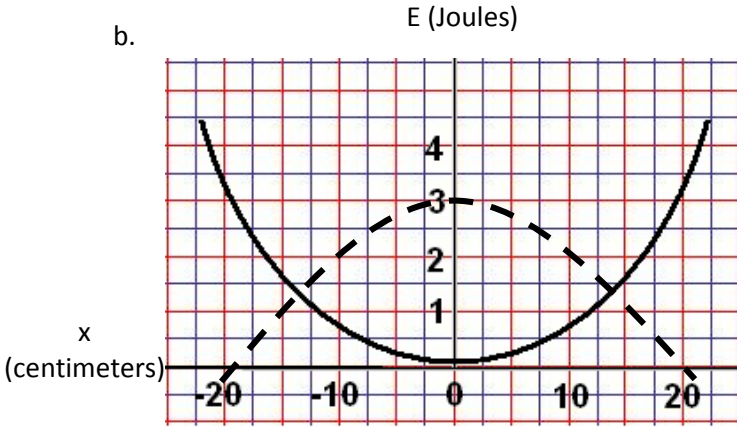
4.

a.



Total Energy is a straight line (dashed) at 3 J.

b.

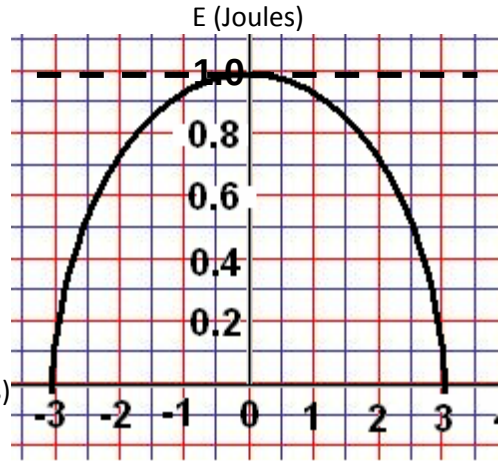


Kinetic Energy is a negative parabola (dashed) that intersects the y-axis at 3 J and the x-axis at -20 cm and 20 cm.

c. 0.2 m
d. 0.422 J (0.5 J)
e. 2.578 J (2.5 J)
f. 0.141 m (0.15 m)
g. 0.397 s

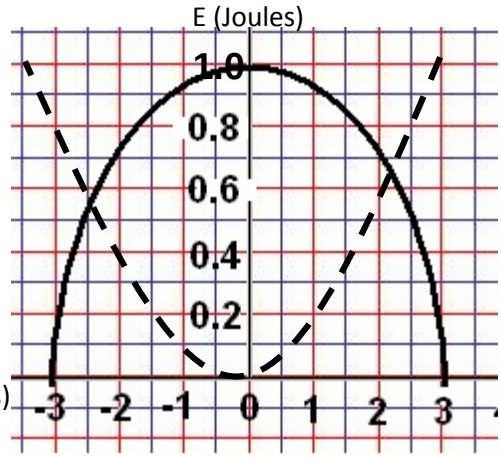
5.

a.



Total Energy is a straight line (dashed) at 1.0 J.

b.

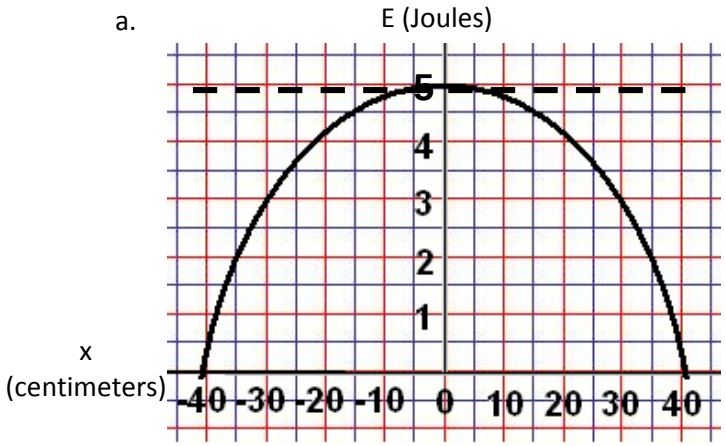


Potential Energy is a positive parabola (dashed) that intersects the Total Energy curve at -3 cm and 3 cm.

c. 0.03 m
d. 0.44 J (0.3 J)
e. 0.56 J (0.7 J)
f. 0.0212 m (0.25 m)
g. 0.084 s

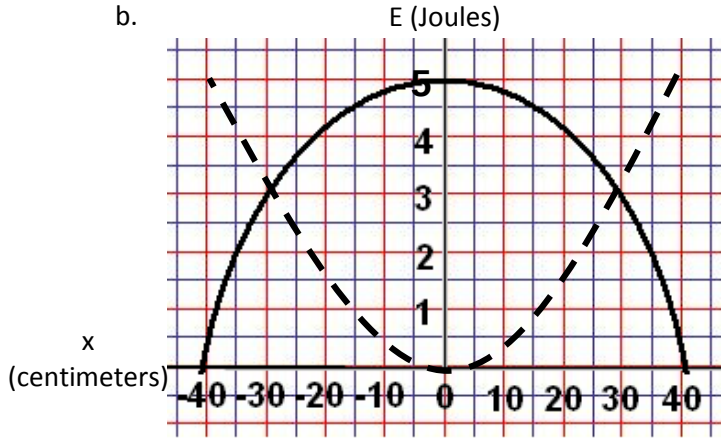
6.

a.



Total Energy is a straight line (dashed) at 5 J.

b.



Potential Energy is a positive parabola (dashed) that intersects the Total Energy curve at -40 cm and 40 cm.

c. 0.40 m
d. 1.25 J (1 J)
e. 3.75 J (4 J)
f. 0.31 m (0.35 m)
g. 0.7108 s