Base your answers to questions 1 through 5 on the diagram below which represents a 3.0-kilogram mass being moved at a constant speed by a force of 6.0 Newtons.

1. What is the change in the kinetic energy of the mass as it moves from point M to point N?
   1) 24 J
   2) 18 J
   3) 6 J
   4) 0 J

2. If energy is supplied at the rate of 10 watts, how much work is done during 2 seconds?
   1) 20 J
   2) 15 J
   3) 10 J
   4) 5 J

3. The magnitude of the force of friction acting on the mass is
   1) 0 N
   2) 1.8 N
   3) 3 N
   4) 6 N

4. If the surface were frictionless, the 6.0-newton force would produce an acceleration of
   1) 0.33 m/s²
   2) 2 m/s²
   3) 6 m/s²
   4) 18 m/s²

5. If the 3.0-kilogram mass were raised 4 meters from the surface, its gravitational potential energy would increase by approximately
   1) 120 J
   2) 40 J
   3) 30 J
   4) 12 J

6. If the velocity of a moving object is doubled, the object's kinetic energy is
   1) unchanged
   2) halved
   3) doubled
   4) quadrupled
7. The kinetic energy of the object at point B is
   1) 1,000 J
   2) 500 J
   3) 100 J
   4) 50 J

8. What distance did the object travel in moving from point A to point B?
   1) 2.5 m
   2) 10. m
   3) 20. m
   4) 100 m

9. Compared to the impulse required to stop the object at point B, the impulse required to stop the object at point C is
   1) less
   2) greater
   3) the same

10. The object comes to rest at a vertical height of S (point D) when θ = 30°. If θ were increased to 40°, the object would come to rest at a vertical height
    1) less than S
    2) greater than S
    3) equal to S

11. The kinetic energy of the moving object is
    1) 5 J
    2) 10 J
    3) 15 J
    4) 50 J

12. The work done by the force in pulling the object from A to B is
    1) 50 J
    2) 100 J
    3) 500 J
    4) 600 J

13. The work done against gravity in moving the object from point A to point B is approximately
    1) 100 J
    2) 200 J
    3) 500 J
    4) 600 J

14. The magnitude of the momentum of the moving object is
    1) 0 kg-m/s
    2) 10 kg-m/s
    3) 100 kg-m/s
    4) 600 kg-m/s
Base your answers to questions 15 through 18 on the diagram below which represents two objects at rest on a frictionless horizontal surface with a spring compressed between them. When the compressed spring is released, the two objects are pushed apart.

![Diagram of two objects and a spring](image)

15. What kinetic energy does the 2.0-kilogram object have after gaining a velocity of 5.0 meters per second?
   1) 25 J  
   2) 20. J  
   3) 10. J  
   4) 5.0 J

16. What is the total momentum of the two-object system after the expansion of the spring?
   1) 20. kg-m/s  
   2) 10. kg-m/s  
   3) 5.0 kg-m/s  
   4) 0 kg-m/s

17. What is the velocity of the 2.0-kilogram object after being acted on by 10. Newton-seconds of impulse?
   1) 1.0 m/s  
   2) 2.0 m/s  
   3) 5.0 m/s  
   4) 10. m/s

18. If the 1.0-kilogram object receives an impulse of +20.-newton-seconds, what impulse does the 2.0-kilogram object receive?
   1) 0 N-s  
   2) -5.0 N-s  
   3) -10. N-s  
   4) -20. N-s

19. A student rides a bicycle up a 30." hill at a constant speed of 6.00 meters per second. The combined mass of the student and bicycle is 70.0 kilograms. What is the kinetic energy of the student-bicycle system during this ride?
   1) 210. J  
   2) 420. J  
   3) 1,260 J  
   4) 2,520 J

20. A cart of mass $m$ traveling at speed $v$ has kinetic energy $KE$. If the mass of the cart is doubled and its speed is halved, the kinetic energy of the cart will be
   1) half as great  
   2) twice as great  
   3) one-fourth as great  
   4) four times as great

21. Which cart shown below has the greatest kinetic energy?
   1)  
   2)  
   3)  
   4)  

   ![Cart options](image)
22. An object moving at a constant speed of 25 meters per second possesses 450 joules of kinetic energy. What is the object’s mass?

1) 0.72 kg  
2) 1.4 kg  
3) 18 kg  
4) 36 kg

23. A 1.0-kilogram rubber ball traveling east at 4.0 meters per second hits a wall and bounces back toward the west at 2.0 meters per second. Compared to the kinetic energy of the ball before it hits the wall, the kinetic energy of the ball after it bounces off the wall is

1) one-fourth as great  
2) one-half as great  
3) the same  
4) four times as great

24. Which graph best represents the relationship between the kinetic energy, $KE$, and the velocity of an object accelerating in a straight line?

1)  
2)  
3)  
4) 

25. If the speed of a car is doubled, the kinetic energy of the car is

1) quadrupled  
2) quartered  
3) doubled  
4) halved

26. The table below lists the mass and speed of each of four objects.

<table>
<thead>
<tr>
<th>Objects</th>
<th>Mass (kg)</th>
<th>Speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td>B</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>C</td>
<td>0.5</td>
<td>4.0</td>
</tr>
<tr>
<td>D</td>
<td>4.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Which two objects have the same kinetic energy?

1) $A$ and $D$  
2) $B$ and $D$  
3) $A$ and $C$  
4) $B$ and $C$

27. As a ball falls freely toward the earth, its kinetic energy

1) decreases  
2) increases  
3) remains the same
28. The object's kinetic energy at point $C$ is less than its kinetic energy at point

1) $A$
2) $B$
3) $D$
4) $E$

29. As the object moves from point $A$ to point $D$, the sum of its gravitational potential and kinetic energies

1) decreases, only
2) decreases and then increases
3) increases and then decreases
4) remains the same

30. The object will have a minimum gravitational potential energy at point

1) $A$
2) $B$
3) $C$
4) $D$

31. The object's kinetic energy at point $D$ is equal to

1) $Mgd$
2) $Mg(d + h)$
3) $mgh$
4) $Mg(h – d)$

32. As an object moves upward at a constant speed, its kinetic energy

1) decreases
2) increases
3) remains the same

33. The diagram below shows block $A$, having mass $2m$ and speed $v$, and block $B$ having mass $m$ and speed $2v$.

Compared to the kinetic energy of block $A$, the kinetic energy of block $B$ is

1) the same
2) twice as great
3) one-half as great
4) four times as great

34. If the direction of a moving car changes and its speed remains constant, which quantity must remain the same?

1) velocity
2) momentum
3) displacement
4) kinetic energy
35. The potential energy of the box at the top of the incline was approximately
   1) 1,000 J
   2) 500 J
   3) 50 J
   4) 0 J

36. How many seconds will it take the box to reach the bottom of the incline?
   1) 2.8 sec.
   2) 2.0 sec.
   3) 4.6 sec.
   4) 4.0 sec.

---

37. If the gravitational potential energy of the cart at point A is zero, the gravitational potential energy of the cart at point C is
   1) 4.9 J
   2) 10 J
   3) 49 J
   4) 98 J

38. What is the magnitude of the external force $F$ necessary to hold the cart motionless at point C?
   1) 4.9 nt.
   2) 2.0 nt.
   3) 9.8 nt.
   4) 19.6 nt.

39. If the cart were allowed to move from point C to point A, the gravitational potential energy of the cart would
   1) decrease
   2) increase
   3) remain the same
40. Compared to the magnitude of the external force \( F \) required to hold the cart at point \( C \) on the frictionless surface, the magnitude of the external force \( F \) required to hold the cart at point \( C \), if friction were present, is

1) less
2) greater
3) the same

41. In the accompanying diagram, a 1.0-kilogram sphere at point \( A \) has a potential energy of 5.0 joules.

What is the potential energy of the sphere at point \( B \), halfway down the incline?

1) 0.0 J
2) 2.5 J
3) 3.0 J
4) 5.0 J

42. If a 5-kilogram mass is raised vertically 2 meters from the surface of the Earth, its gain in potential energy is approximately

1) 0 J
2) 10 J
3) 20 J
4) 100 J

43. A 20.-newton block falls freely from rest from a point 3.0 meters above the surface of the Earth. With respect to the surface of the Earth, what is the gravitational potential energy of the block-Earth system after the block has fallen 1.5 meters?

1) 20. J
2) 30. J
3) 60. J
4) 120 J

44. As an object slides across a horizontal surface, the gravitational potential energy of the object will

1) decrease
2) increase
3) remain the same

45. A ball is thrown upward from the Earth's surface. While the ball is rising, its gravitational potential energy will

1) decrease
2) increase
3) remain the same

46. Which mass has the greatest potential energy with respect to the floor?

1) 50-kg mass resting on the floor
2) 2-kg mass 10 meters above the floor
3) 10-kg mass 2 meters above the floor
4) 6-kg mass 5 meters above the floor
Base your answers to questions 47 through 51 on the diagram below. Which represents a 2.0-kilogram mass placed on a frictionless track at point A and released from rest. Assume the gravitational potential energy of the system to be zero at point E.

47. The gravitational potential energy of the system at point A is approximately
   1) 80. J
   2) 20. J
   3) 8.0 \times 10^2 \text{ J}
   4) 7.0 \times 10^2 \text{ J}

48. Compared to the kinetic energy of the mass at point B, the kinetic energy of the mass at point E is
   1) \frac{1}{2} \text{ as great}
   2) twice as great
   3) the same
   4) 4 times greater

49. As the mass travels along the track, the maximum height it will reach above point E will be closest to
   1) 10. m
   2) 20. m
   3) 30. m
   4) 40. m

50. If the mass were released from rest at point B, its speed at point C would be
   1) 0. m/s
   2) 0.50 m/s
   3) 10. m/s
   4) 14 m/s

51. Compared to the total mechanical energy of the system at point A, the total mechanical energy of the system at point F is
   1) less
   2) more
   3) the same

52. Which graph best represents the relationship between potential energy (PE) and height above ground (h) for a freely falling object released from rest?

1) \[
\begin{array}{c}
\text{PE} \\
\hline
\text{h}
\end{array}
\]

2) \[
\begin{array}{c}
\text{PE} \\
\hline
\text{h}
\end{array}
\]

3) \[
\begin{array}{c}
\text{PE} \\
\hline
\text{h}
\end{array}
\]

4) \[
\begin{array}{c}
\text{PE} \\
\hline
\text{h}
\end{array}
\]
Base your answers to questions 53 through 57 on the diagram below which represents a simple pendulum with a 2.0-kilogram bob and a length of 10.0 meters. The pendulum is released from rest at position 1 and swings without friction through position 4. At position 3, its lowest point, the speed of the bob is 6.0 meters per second.

53. What is the potential energy of the bob at position 1 in relation to position 3?
   1) 18 J
   2) 36 J
   3) 72 J
   4) 180 J

54. At which position does the bob have its maximum kinetic energy?
   1) 1
   2) 2
   3) 3
   4) 4

55. At position 4, the centripetal force on the bob is directed toward point
   1) A
   2) B
   3) C
   4) D

56. What is the centripetal acceleration of the bob at position 3?
   1) 1.8 m/s²
   2) 3.6 m/s²
   3) 7.2 m/s²
   4) 36 m/s²

57. Compared to the sum of the kinetic and potential energies of the bob at position 1, the sum of the kinetic and potential energies of the bob at position 3
   1) less
   2) greater
   3) the same

58. The diagram below represents a cart traveling from left to right along a frictionless surface with an initial speed of v. At which point is the gravitational potential energy of the cart least?
   1) A
   2) B
   3) C
   4) D
59. As the pendulum swings freely from $A$ to $B$ as shown in the diagram to the right, the gravitational potential energy of the ball

1) decreases
2) increases
3) remains the same

60. Three people of equal mass climb a mountain using paths $A$, $B$, and $C$ shown in the diagram below.

Along which path(s) does a person gain the greatest amount of gravitational potential energy from start to finish?

1) $A$, only
2) $B$, only
3) $C$, only
4) The gain is the same along all paths.

Base your answers to questions 61 through 63 on the diagram below which represents a frictionless track. A 10-kilogram block starts from rest at point $A$ and slides along the track.

61. What is the approximate potential energy of the block at point $C$?

1) 20 J
2) 200 J
3) 300 J
4) 500 J

62. As the block moves from point $A$ to point $B$, the total amount of gravitational potential energy changed to kinetic energy is approximately

1) 5 J
2) 20 J
3) 50 J
4) 500 J

63. What is the approximate speed of the block at point $B$?

1) 1 m/s
2) 10 m/s
3) 50 m/s
4) 100 m/s
64. A mass resting on a shelf 10.0 meters above the floor has a gravitational potential energy of 980. joules with respect to the floor. The mass is moved to a shelf 8.00 meters above the floor. What is the new gravitational potential energy of the mass?

1) 960. J
2) 784 J
3) 490. J
4) 196 J

65. The diagram below shows a 1.5-kilogram kitten jumping from the top of a 1.80-meter-high refrigerator to a 0.90-meter-high counter.

Compared to the kitten's gravitational potential energy on top of the refrigerator, the kitten's gravitational potential energy on top of the counter is

1) half as great
2) twice as great
3) one-fourth as great
4) four times as great

66. Each of the blocks in the diagrams below is lifted vertically for the distance indicated. Which block will gain the most gravitational potential energy?

Base your answers to questions 67 and 68 on the diagram below which shows a 1-kilogram mass and a 2-kilogram mass being dropped from a building 100 meters high.

67. The potential energy at the top of the building is

1) greater for the 1-kilogram mass
2) greater for the 2-kilogram mass
3) the same for both masses

68. Halfway down, the acceleration is

1) greater for the 1-kilogram mass
2) greater for the 2-kilogram mass
3) the same for both masses
69. A girl rides an escalator that moves her upward at constant speed. As the girl rises, how do her gravitational potential energy and kinetic energy change?

1) Gravitational potential energy decreases and kinetic energy decreases.
2) Gravitational potential energy decreases and kinetic energy remains the same.
3) Gravitational potential energy increases and kinetic energy decreases.
4) Gravitational potential energy increases and kinetic energy remains the same.

70. Which graph best represents the relationship between the gravitational potential energy of a freely falling object and the object’s height above the ground near the surface of Earth?

71. What is the gravitational potential energy with respect to the surface of the water of a 75.0 kilogram diver located 3.00 meters above the water?

1) \(2.17 \times 10^4\) J
2) \(2.21 \times 10^3\) J
3) \(2.25 \times 10^2\) J
4) \(2.29 \times 10^1\) J

72. A 1.0-kilogram book resting on the ground is moved 1.0 meter at various angles relative to the horizontal. In which direction does the 1.0-meter displacement produce the greatest increase in the book’s gravitational potential energy?

1) 

2) 

3) 

4)
73. Which graph best represents the relationship between the gravitational potential energy of an object near the surface of Earth and its height above Earth’s surface?

![Graphs](image)

1)  
2)  
3)  
4)  

74. A pendulum is pulled to the side and released from rest. Which graph best represents the relationship between the gravitational potential energy of the pendulum and its displacement from its point of release?

![Graphs](image)

1)  
2)  
3)  
4)  

75. What is the spring constant of a spring of negligible mass which gained 8 joules of potential energy as a result of being compressed 0.4 meter?

1) 100 N/m  
2) 50 N/m  
3) 0.3 N/m  
4) 40 N/m

76. Which graph best represents the relationship between the elongation of a spring whose elastic limit has not been reached and the force applied to it?

![Graphs](image)

1)  
2)  
3)  
4)  

77. Graph A and B below represent the results of applying an increasing force to stretch a spring which did not exceed its elastic limit.

![Graphs](image)

The spring constant can be represented by the

1) slope of graph A  
2) slope of graph B  
3) reciprocal of the slope of graph A  
4) reciprocal of the slope of graph B
78. A force of 0.2 Newton is needed to compress a spring a distance of 0.02 meter. The potential energy stored in this compressed spring is

1) $8 \times 10^{-5}$ J
2) $2 \times 10^{-3}$ J
3) $2 \times 10^{-5}$ J
4) $4 \times 10^{-5}$ J

79. When a spring is stretched 0.200 meter from its equilibrium position, it possesses a potential energy of 10.0 joules. What is the spring constant for this spring?

1) 100. N/m
2) 125 N/m
3) 250. N/m
4) 500. N/m

80. In the diagram below, a student compresses the spring in a pop-up toy 0.020 meter. If the spring has a spring constant of 340 newtons per meter, how much energy is being stored in the spring?

![](Uncompressed_spring.png)

1) 0.068 J
2) 0.14 J
3) 3.4 J
4) 6.8 J

81. The graph below represents the elongation of a spring as a function of the applied force.

![Force vs. Elongation graph](Force_vs_Elongation.png)

How much work must be done to stretch the spring 0.40 meter?

1) 4.8 J
2) 6.0 J
3) 9.8 J
4) 24 J
82. Which graph best represents the elastic potential energy stored in a spring ($PE_s$) as a function of its elongation, $x$?

[Graphs 1 to 4]

83. As a spring is stretched, its elastic potential energy

1) decreases
2) increases
3) remains the same

84. As shown in the diagram below, a 0.50-meter-long spring is stretched from its equilibrium position to a length of 1.00 meter by a weight.

If 15 joules of energy are stored in the stretched spring, what is the value of the spring constant?

1) 30. N/m
2) 60. N/m
3) 120 N/m
4) 240 N/m
85. Base your answer to the following question on the information and graph below.

The graph represents the relationship between the force applied to each of two springs, A and B, and their elongations.

A 1.0-kilogram mass is suspended from each spring. If each mass is at rest, how does the potential energy stored in spring A compare to the potential energy stored in spring B?

86. What is the work required to raise a 10.-kilogram box from the surface of the earth to a height of 5.0 meters?

1) 50 J
2) 100 J
3) 200 J
4) 490 J

87. A force of 100. Newtons is used to push a trunk to the top of an incline 3.0 meters long. Then a force of 50. Newtons is used to push the trunk for 10. meters along a horizontal platform. What is the total work done on the trunk?

1) 8.0 × 10² J
2) 5.0 × 10² J
3) 3.0 × 10² J
4) 9.0 × 10² J

88. The graph below shows the force exerted on a block as a function of the block's displacement in the direction of the force.

How much work did the force do in displacing the block 5.0 meters?

1) 0 J
2) 20. J
3) 0.80 J
4) 4.0 J

89. How much work is done on a downhill skier by an average braking force of 9.8 × 10² Newtons to stop her in a distance of 10. meters?

1) 1.0 × 10¹ J
2) 9.8 × 10¹ J
3) 1.0 × 10³ J
4) 9.8 × 10³ J

90. If a 2.0-kilogram mass is raised 0.05 meter vertically, the work done on the mass is approximately

1) 0.10 J
2) 0.98 J
3) 40. J
4) 100 J
91. Which action would require no work to be done on an object?

1) lifting the object from the floor to the ceiling
2) pushing the object along a horizontal floor against a frictional force
3) decreasing the speed of the object until it comes to rest
4) holding the object stationary above the ground

92. In the diagram below, a 20.0-newton force is used to push a 2.00-kilogram cart a distance of 5.00 meters.

The work done on the cart is

1) 100. J
2) 200. J
3) 150. J
4) 40.0 J

93. A constant force of 1900 Newtons is required to keep an automobile having a mass of $1.0 \times 10^3$ kilograms moving at a constant speed of 20. meters per second. The work done in moving the automobile a distance of $2.0 \times 10^3$ meters is

1) $2.0 \times 10^4$ J
2) $3.8 \times 10^4$ J
3) $2.0 \times 10^6$ J
4) $3.8 \times 10^6$ J

94. The diagram below shows points $A$, $B$, and $C$ at or near Earth’s surface. As a mass is moved from $A$ to $B$, 100. joules of work are done against gravity.

What is the amount of work done against gravity as an identical mass is moved from $A$ to $C$?

1) 100. J
2) 200. J
3) 173 J
4) 273 J
95. A box is pushed to the right with a varying horizontal force. The graph below represents the relationship between the applied force and the distance the box moves.

What is the total work done in moving the box 6.0 meters?

1) 9.0 J  
2) 18 J  
3) 27 J  
4) 36 J

96. As shown in the diagram below, a child applies a constant 20.-newton force along the handle of a wagon which makes a 25° angle with the horizontal.

How much work does the child do in moving the wagon a horizontal distance of 4.0 meters?

1) 5.0 J  
2) 34 J  
3) 73 J  
4) 80. J

97. A horizontal force of 40 Newtons pushes a block along a level table at a constant speed of 2 meters per second. How much work is done on the block in 6 seconds?

1) 80 J  
2) 120 J  
3) 240 J  
4) 480 J

98. A box is dragged up an incline a distance of 8 meters with a force of 50 Newtons. If the increase in potential energy of the box is 300 joules, the work done against friction is

1) 100 J  
2) 200 J  
3) 300 J  
4) 400 J
99. A force of 3 Newtons moves a 10-kilogram mass horizontally a distance of 3 meters at constant velocity. The work done against friction is
1) 6 J
2) 9 J
3) 3 J
4) 30 J

100. In the diagram below, 55 joules of work is needed to raise a 10.-newton weight 5.0 meters.

How much work is done to overcome friction as the weight is raised?
1) 5 J
2) 5.5 J
3) 11 J
4) 50. J

101. A force causes an object on a horizontal surface to overcome friction and begin to move. As this happens, the object's internal energy will
1) decrease
2) increase
3) remain the same

102. A student pulls a block 3.0 meters along a horizontal surface at constant velocity. The diagram below shows the components of the force exerted on the block by the student.

How much work is done against friction?
1) 18 J
2) 24 J
3) 30. J
4) 42 J

103. The diagram below shows a 5.0-kilogram mass sliding 9.0 meters down an incline from a height of 2.0 meters in 3.0 seconds. The object gains 90. joules of kinetic energy while sliding.

How much work is done against friction as the mass slides the 9.0 meters?
1) 0 J
2) 8 J
3) 45 J
4) 90. J
104. A block weighing 15 Newtons is pulled to the top of an incline that is 0.20 meter above the ground, as shown below.

If 4.0 joules of work are needed to pull the block the full length of the incline, how much work is done against friction?

1) 1.0 J
2) 0.0 J
3) 3.0 J
4) 7.0 J

105. A constant force is used to keep a block sliding at constant velocity along a rough horizontal track. As the block slides, there could be an increase in its

1) gravitational potential energy, only
2) internal energy, only
3) gravitational potential energy and kinetic energy
4) internal energy and kinetic energy

106. As shown in the diagram below, a student exerts an average force of 600. newtons on a rope to lift a 50.0-kilogram crate a vertical distance of 3.00 meters.

Compared to the work done by the student, the gravitational potential energy gained by the crate is

1) exactly the same
2) 330 J less
3) 330 J more
4) 150 J more

107. One elevator lifts a mass a given height in 10 seconds and a second elevator does the same work in 5 seconds. Compared to the power developed by the first elevator, the power developed by the second elevator is

1) one-half as great
2) twice as great
3) the same
4) four times as great

108. An electrical heater raises the temperature of a measured quantity of water. The water absorbs 6,000 joules of energy from the heater in 30.0 seconds. What is the minimum power supplied to the heater?

1) $5.00 \times 10^2$ W
2) $2.00 \times 10^2$ W
3) $1.80 \times 10^3$ W
4) $2.00 \times 10^3$ W
109. A motor has an output of 1,000 watts. When the motor is working at full capacity, how much time will it require to lift a 50-newton weight 100 meters?

1) 5 s  
2) 10 s  
3) 50 s  
4) 100 s

110. A student running up a flight of stairs increases her speed at a constant rate. Which graph best represents the relationship between work and time for the student's run up the stairs?

1)  
2)  
3)  
4)  

111. The graph below represents the relationship between the work done by a student running up a flight of stairs and the time of ascent.

```
Work vs. Time

Work (joules)

Time (seconds)
```

What does the slope of this graph represent?

1) impulse  
2) momentum  
3) speed  
4) power

112. A 40-kilogram student runs up a staircase to a floor that is 5.0 meters higher than her starting point in 7.0 seconds. The student’s power output is

1) 29 W  
2) 280 W  
3) $1.4 \times 10^3$ W  
4) $1.4 \times 10^4$ W
113. A 110-kilogram bodybuilder and his 55-kilogram friend run up identical flights of stairs. The bodybuilder reaches the top in 4.0 seconds while his friend takes 2.0 seconds. Compared to the power developed by the bodybuilder while running up the stairs, the power developed by his friend is

1) the same
2) twice as much
3) half as much
4) four times as much

114. A force of 70 Newtons must be exerted to keep a car moving with a constant speed of 10 meters per second. What is the rate at which energy must be supplied?

1) 1/7 W
2) 7.0 W
3) 700 W
4) 7,000 W

115. A 6.0 × 10²-Newton man climbing a rope at a speed of 2.0 meters per second develops power at the rate of

1) 1.2 × 10³ W
2) 6.0 × 10⁶ W
3) 3.0 × 10² W
4) 1.2 × 10³ W

116. A 2000-watt motor working at full capacity can vertically lift a 400-newton weight at a constant speed of

1) 2 × 10³ m/s
2) 50 m/s
3) 5 m/s
4) 0.2 m/s

117. A boat weighing 9.0 × 10² Newtons requires a horizontal force of 6.0 × 10² Newtons to move it across the water at 1.5 × 10¹ meters per second. The boat’s engine must provide energy at the rate of

1) 2.5 × 10⁻² J
2) 4.0 × 10¹ W
3) 7.5 × 10³ J
4) 9.0 × 10³ W

118. Which graph best represents the relationship between the power required to raise an elevator and the speed at which the elevator rises?
119. A machine does work at the rate of 600 watts. How much weight will be lifted 10 meters in 10 seconds?

1) 6 N  
2) 60 N  
3) 600 N  
4) 6,000 N

120. A crane raises a 200-newton weight to a height of 50 meters in 5 seconds. The crane does work at the rate of

1) $8 \times 10^{-1}$ W  
2) $2 \times 10^1$ W  
3) $2 \times 10^3$ W  
4) $5 \times 10^4$ W

121. What is the minimum power required for a conveyor to raise an 8.0-newton box 4.0 meters vertically in 8.0 seconds?

1) 260 W  
2) 64 W  
3) 32 W  
4) 4.0 W

122. The diagram below shows a 1.0 $\times$ 10³-Newton crate to be lifted at constant speed from the ground to a loading dock 1.5 meters high in 5.0 seconds.

What power is required to lift the crate?

1) $1.5 \times 10^3$ W  
2) $2.0 \times 10^2$ W  
3) $3.0 \times 10^2$ W  
4) $7.5 \times 10^3$ W
123. A 3.0-kilogram block is initially at rest on a frictionless, horizontal surface. The block is moved 8.0 meters in 2.0 seconds by the application of a 12-newton horizontal force, as shown in the diagram below.

![Diagram of a 3.0 kg block moved 8.0 m with a 12 N force](image)

What is the average power developed while moving the block?

1) 24 W
2) 32 W
3) 48 W
4) 96 W

124. What is the average power developed by a motor as it lifts a 400.-kilogram mass at constant speed through a vertical distance of 10.0 meters in 8.0 seconds?

1) 320 W
2) 500 W
3) 4,900 W
4) 32,000 W

125. A baseball bat strikes a ball with an average force of $2.0 \times 10^4$ Newtons. If the bat stays in contact with the ball for a distance of $5.0 \times 10^{-3}$ meter, what kinetic energy will the ball acquire from the bat?

1) $1.0 \times 10^2$ J
2) $2.0 \times 10^2$ J
3) $2.5 \times 10^1$ J
4) $4.0 \times 10^2$ J

126. A person does 100 joules of work in pulling back the string of a bow. What will be the initial speed of a 0.5-kilogram arrow when it is fired from the bow?

1) 20 m/s
2) 50 m/s
3) 200 m/s
4) 400 m/s

127. As shown in the diagram below, pulling a 9.8-newton cart a distance of 0.50 meter along a plane inclined at 15º requires 1.3 joules of work.

![Diagram of a 9.8N cart pulled 0.50 m along a 15º plane](image)

If the cart were raised 0.50 meter vertically instead of being pulled along the inclined plane, the amount of work done would be

1) less
2) greater
3) the same
128. A 10.0-kilogram mass falls freely a distance of 6.0 meters near the Earth's surface. The total kinetic energy gained by the mass as it falls is approximately

1) 60.0 J
2) 590 J
3) 720 J
4) 1,200 J

129. Sixteen joules of work was required to lift a 2.0-kilogram object from the floor to a table. How much potential energy was gained by the 2.0-kilogram object?

1) 0.80 joule
2) 8.0 joules
3) 16 joules
4) 32 joules

130. In the diagram below, an average force of 20.0 Newtons is used to pull back the string of a bow 0.60 meter. As the arrow, leaves the bow, its kinetic energy is

As the arrow, leaves the bow, its kinetic energy is

1) 3.4 J
2) 6.0 J
3) 12 J
4) 33 J

131. A 0.10-kilogram ball dropped vertically from a height of 1.00 meter above the floor bounces back to a height of 0.80 meter. The mechanical energy lost by the ball as it bounces is

1) 0.080 J
2) 0.20 J
3) 0.30 J
4) 0.78 J

132. A catapult with a spring constant of $1.0 \times 10^4$ newtons per meter is required to launch an airplane from the deck of an aircraft carrier. The plane is released when it has been displaced 0.50 meter from its equilibrium position by the catapult. The energy acquired by the airplane from the catapult during takeoff is approximately

1) $1.3 \times 10^3$ J
2) $2.0 \times 10^4$ J
3) $2.5 \times 10^3$ J
4) $1.0 \times 10^4$ J

133. The diagram below shows a 0.1-kilogram apple attached to a branch of a tree 2 meters above a spring on the ground below.

The apple falls and hits the spring, compressing it 0.1 meter from its rest position. If all of the gravitational potential energy of the apple on the tree is transferred to the spring when it is compressed, what is the spring constant of this spring?

1) 10 N/m
2) 40 N/m
3) 100 N/m
4) 400 N/m
134. A horizontal force of 5.0 newtons acts on a 3.0-kilogram mass over a distance of 6.0 meters along a horizontal, frictionless surface. What is the change in kinetic energy of the mass during its movement over the 6.0-meter distance?

1) 6.0 J
2) 15 J
3) 30. J
4) 90. J

135. The diagram below shows a moving, 5.00-kilogram cart at the foot of a hill 10.0 meters high. For the cart to reach the top of the hill, what is the minimum kinetic energy of the cart in the position shown? [Neglect energy loss due to friction.]

1) 4.91 J
2) 50.0 J
3) 250. J
4) 491 J

136. At a height of 10 meters above the earth's surface, the potential energy of a 2-kilogram mass is 196 joules. After the mass which starts at rest falls 5 meters, its kinetic energy will be

1) 196 J
2) 147 J
3) 98 J
4) 49 J

137. A 40-newton object is released from rest at a height of 10 meters above the earth's surface. Just before it hits the ground, its kinetic energy will be closest to

1) 0 joules
2) 400 joules
3) 800 joules
4) 1,200 joules

Base your answers to questions 138 through 140 on the diagram below which represents an object M suspended by a string from point P. When object M is swung to a height of h and released, it passes through the rest position at a speed of 10 meters per second.

138. The height h from which the object was released is approximately

1) 8 m
2) 7 m
3) 5.0 m
4) 2.5 m

139. The centripetal force on object M as it passes through the rest position is approximately

1) 10 N
2) 50 N
3) 100 N
4) 1,000 N
140. The centripetal force on object M could be halved as it passes through the rest position by doubling the

1) weight of the object, only
2) length of the string, only
3) height $h$ and the weight of the object
4) the length of the string and the height $h$

141. A 2.0-newton book falls from a table 1.0 meter high. After falling 0.5 meter, the book's kinetic energy is

1) 1.0 J
2) 2.0 J
3) 10 J
4) 20 J

142. A 2.0-kilogram mass falls freely for 10. meters near the surface of the Earth. The total kinetic energy gained by the object during its free fall is approximately

1) 400 J
2) 200 J
3) 100 J
4) 50 J

143. A 0.50-kilogram sphere at the top of an incline has a potential energy of 6.0 joules relative to the base of the incline. Rolling halfway down the incline will cause the sphere's potential energy to be

1) 0 J
2) 12 J
3) 3.0 J
4) 6.0 J

144. A 20.-kilogram object strikes the ground with 1,960 joules of kinetic energy after falling freely from rest. How far above the ground was the object when it was released?

1) 10. m
2) 14 m
3) 98 m
4) 200 m

145. A cart of mass $M$ on a frictionless track starts from rest at the top of a hill having height $h_1$, as shown in the diagram below.

What is the kinetic energy of the cart when it reaches the top of the next hill, having height $h_2$?

1) $mgh_1$
2) $Mg(h_1-h_2)$
3) $Mg(h_2-h_3)$
4) 0
Base your answers to questions 146 and 147 on the diagram below which represents a block with initial velocity $v_1$ sliding along a frictionless track from point $A$ through point $E$.

146. The kinetic energy of the block will be greatest when it reaches point

1) $A$
2) $B$
3) $C$
4) $D$

147. The velocity of the block will be least at point

1) $A$
2) $B$
3) $C$
4) $E$

---

148. Base your answer to the following question on the diagram below. The diagram represents a 1.00 kilogram object being held at rest on a frictionless incline.

The object is released and slides the length of the incline. When it reaches the bottom of the incline, the object's kinetic energy will be closest to

1) 19.6 J
2) 2.00 J
3) 9.81 J
4) 4.00 J

149. The wrecking crane shown below is moving toward a brick wall which is to be torn down.

At what point in the swing of the wrecking ball should the ball make contact with the wall to make a collision with the greatest kinetic energy?

1) 1
2) 2
3) 3
4) 4
150. A 3.0-kilogram mass is attached to a spring having a spring constant of 30. newtons per meter. The mass is pulled 0.20 meter from the spring's equilibrium position and released. What is the maximum kinetic energy achieved by the mass spring system?

1)  2.4 J  
2)  1.5 J  
3)  1.2 J  
4)  0.60 J
**Reference Tables**

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The potential energy stored in spring $A$ is less than the potential energy stored in spring $B$. 