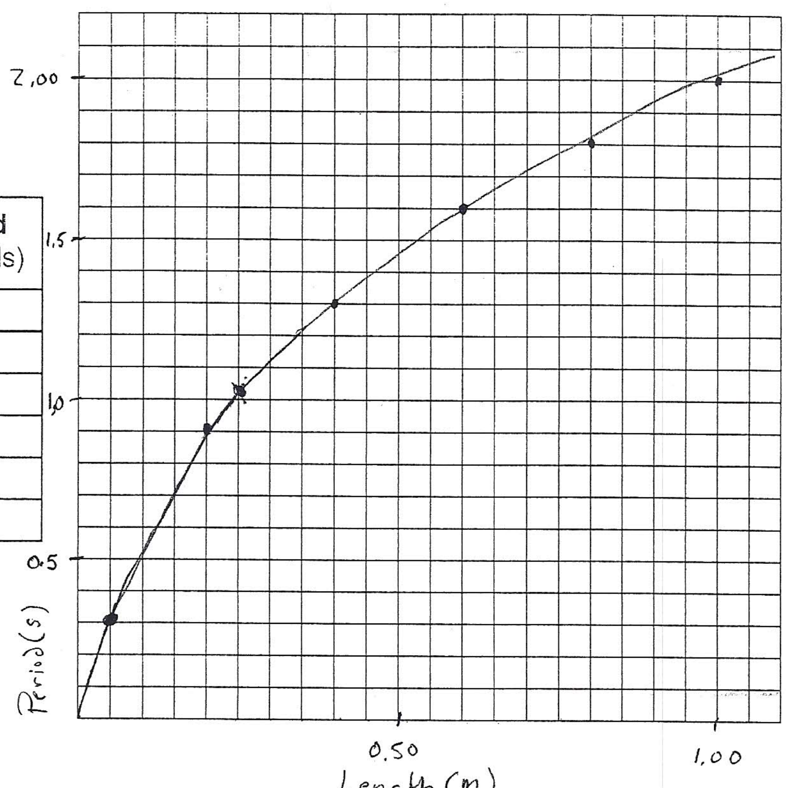
Name: ______________ Date: ______________

1. In a laboratory exercise, a student kept the mass and amplitude of swing of a simple pendulum constant. The length of the pendulum was increased and the period of the pendulum was measured. The student recorded the data in the table below.

Period vs. Length of Pendulum

Length (meters)	Period (seconds)
0.05	0.30
0.20	0.90
0.40	1.30
0.60	1.60
0.80	1.80
1.00	2.00

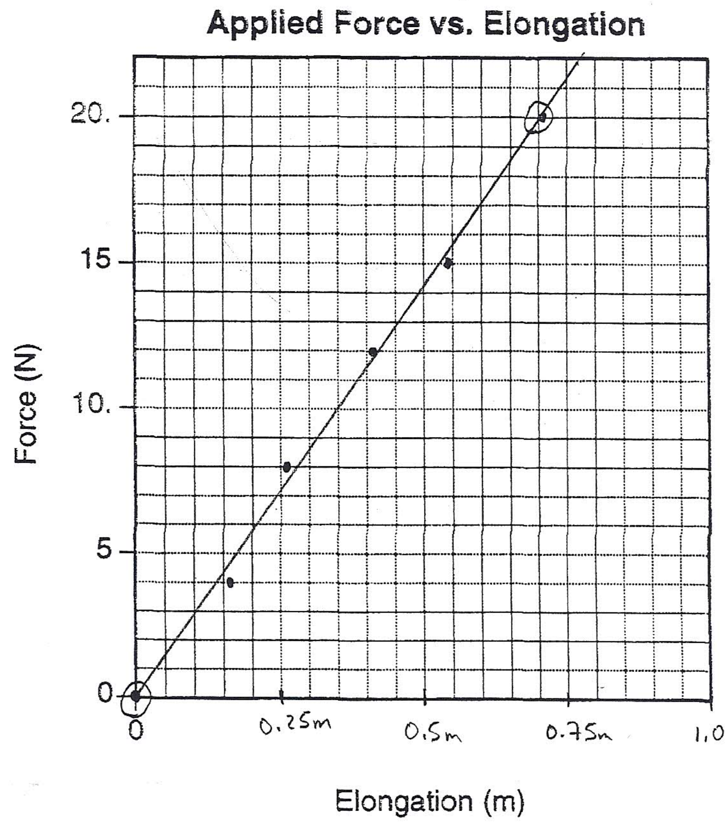


a Label each axis with the appropriate physical quantity and unit. Mark an appropriate scale on each axis.
b Plot the data points for period versus pendulum length.
c Draw the best-fit line or curve for the data graphed.
d Using your graph, determine the period of a pendulum whose length is 0.25 meter.

$T \cong 1.0\,s$

Base your answers to questions 3 through 6 on the information in the data table below. The data were obtained by varying the force applied to a spring and measuring the corresponding elongation of the spring.

Applied Force (N)	Elongation of Spring (m)
0.0	0.00
4.0	0.16
8.0	0.27
12.0	0.42
16.0	0.54
20.0	0.71



3. Using the best-fit line, determine the spring constant of the spring. [Show all calculations, including the equation and substitution with units.]

4. Mark an appropriate scale on the axis labeled "Elongation (m)."

5. Plot the data points for force versus elongation.

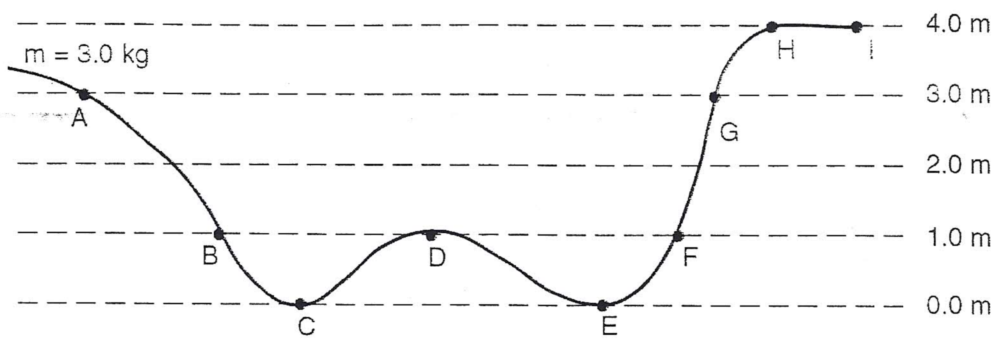
6. Draw the best-fit line.

k = slope

$m = \frac{\Delta y}{\Delta x} = \frac{20N - 0N}{0.7m - 0m} = 28.6 N/m$

Base your answers to questions 7 through 9 on the information and diagram below.

A 3.0-kilogram object is 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 *C*.)



7. Which letter represents the farthest point on the track that the object will reach?

G

8. Calculate the gravitational potential energy of the object at point *A*. [Show all work, including the equation and substitution with units]

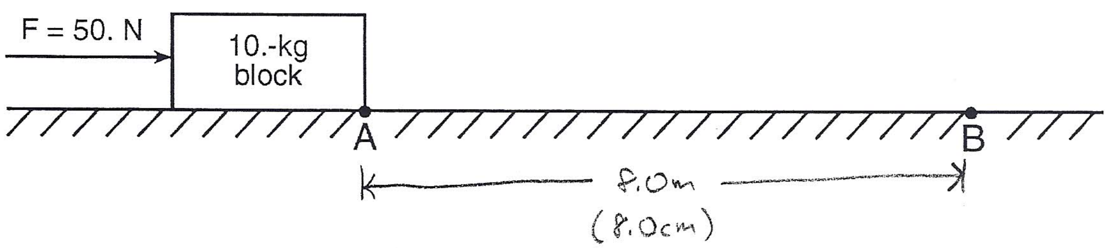
$PE = mg\Delta h = (3.0\,kg)(9.81\,m/s^2)(3\,m) = 883\,J$

9. Calculate the kinetic energy of the object at point *B*. [Show all work, including the equation and substitution with units.]

$KE_f = PE_i - PE_f = mg(h_i - h_f) = (3.0\,kg)(9.81\,m/s^2)(3.0\,m - 1.0\,m) = 590\,J$

Base your answers to questions **10** and **11** on the information and diagram below.

A 10.-kilogram block is pushed across a floor by a horizontal force of 50. newtons. The block moves from point *A* to point *B* in 3.0 seconds.



10. Calculate the power required to move the block from point *A* to point *B* in 3.0 seconds. [Show all work, including the equation and substitution with units.]

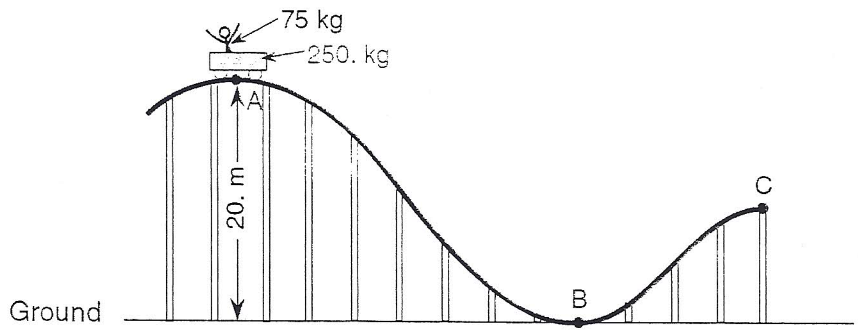
$P = \frac{W}{t} = \frac{F \cdot d}{t} = \frac{(50N)(8.0m)}{(3.0s)} = 133\,W$

11. Using a scale of 1.0 centimeter = 1.0 meter, determine the magnitude of the displacement of the block as it moves from point *A* to point *B*.

$d = 8.0\,m$

Base your answers to questions 12 through 14 on the information and diagram below.

A 250.-kilogram car is initially at rest at point *A* on a roller coaster track. The car carries a 75-kilogram passenger and is 20. meters above the ground at point *A*. [Neglect friction.]



12. Compare the total mechanical energy of the car and passenger at points *A*, *B*, and *C*.

The total mechanical energy ($E_T = PE + KE$) will be the same at points A, B and C.

13. Calculate the speed of the car and passenger at point *B*. [Show all work, including the equation and substitution with units.]

$PE_i = KE_f$

$mgh_i = \frac{1}{2}mv_f^2$

$v_f = \sqrt{2gh_i}$

$= \sqrt{2(9.81 \text{ m/s}^2)(20 \text{ m})} = 19.8 \text{ m/s}$

14. Calculate the total gravitational potential energy, relative to the ground, of the car and the passenger at point *A*. [Show all work, including the equation and substitution with units.]

$PE_i = mgh$

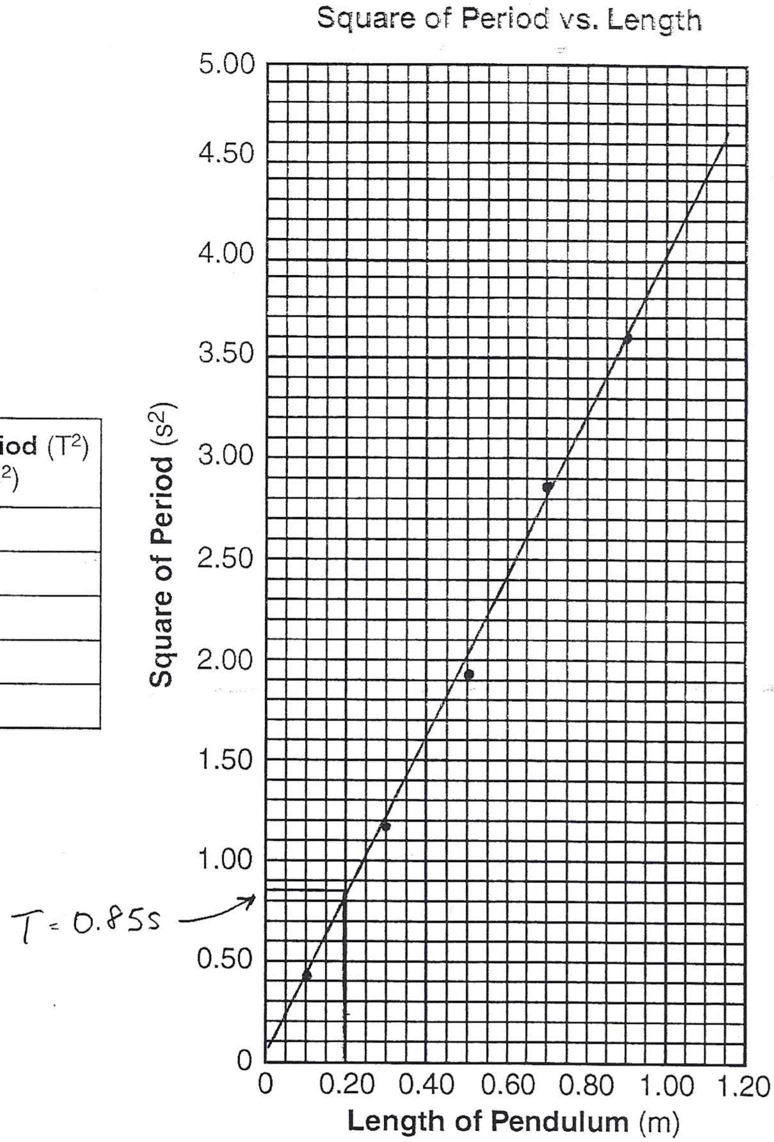
$= (75 \text{ kg} + 250 \text{ kg})(9.81 \text{ m/s}^2)(20 \text{ m})$

$= 63\,800 \text{ J}$

21. Base your answer to the following question on the information and data table below.

In an experiment, a student measured the length and period of a simple pendulum. The data table lists the length (ℓ) of the pendulum in meters and the square of the period (T^2) of the pendulum in seconds^2.

Length (ℓ) (meters)	Square of Period (T^2) (seconds^2)
0.100	0.410
0.300	1.18
0.500	1.91
0.700	2.87
0.900	3.60



a Plot the data points for the square of period versus length.
b Draw the best-fit straight line.
c Using your graph, determine the time in seconds it would take this pendulum to make one complete swing if it were 0.200 meter long.
d The period of a pendulum is related to its length by the formula: $T^2 = (4\pi^2/g) \bullet \ell$ where g represents the acceleration due to gravity. Explain how the graph you have drawn could be used to calculate the value of g.

Solve $T^2 = \frac{4\pi^2 l}{g}$ for g $\longrightarrow$ $g = \frac{4\pi^2 l}{T^2}$ Then substitute the values for l and T off the graph and solve for g.

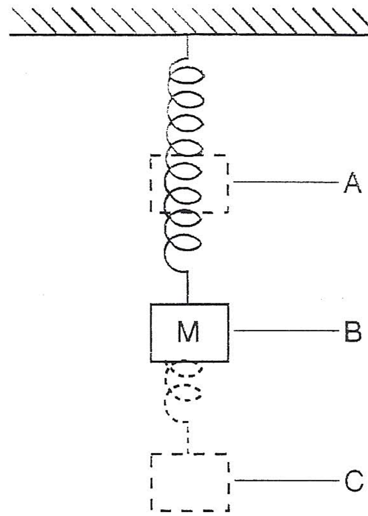
Base your answers to questions 22 and 23 on the information below.

An 8.00-kilogram ball is fired horizontally from a 1.00×10^3-kilogram cannon initially at rest. After having been fired, the momentum of the ball is 2.40×10^3 kilogram•meters per second east. [Neglect friction.]

22. Identify the direction of the cannon's velocity after the ball is fired.
23. Calculate the magnitude of the cannon's velocity after the ball is fired.

Base your answers to questions 24 through 26 on the information and diagram below.

A mass, *M*, is hung from a spring and reaches equilibrium at position *B*. The mass is then raised to position *A* and released. The mass oscillates between positions *A* and *C*. [Neglect friction.]



24. At which position, *A*, *B*, or *C*, is mass *M* located when the elastic potential energy of the system is at a maximum? Explain your choice.
25. At which position, *A*, *B*, or *C*, is mass *M* located when the kinetic energy of the system is at a maximum? Explain your choice.
26. At which position, *A*, *B*, or *C*, is mass *M* located when the gravitational potential energy of the system is at a maximum? Explain your choice.

24. The elastic potential is a maximum at C where the displacement or spring is stretched the most.

25. The kinetic energy is maximized where the speed is the greatest, at position B.

26. The gravitational potential energy is the greatest at A where it has the greatest height.

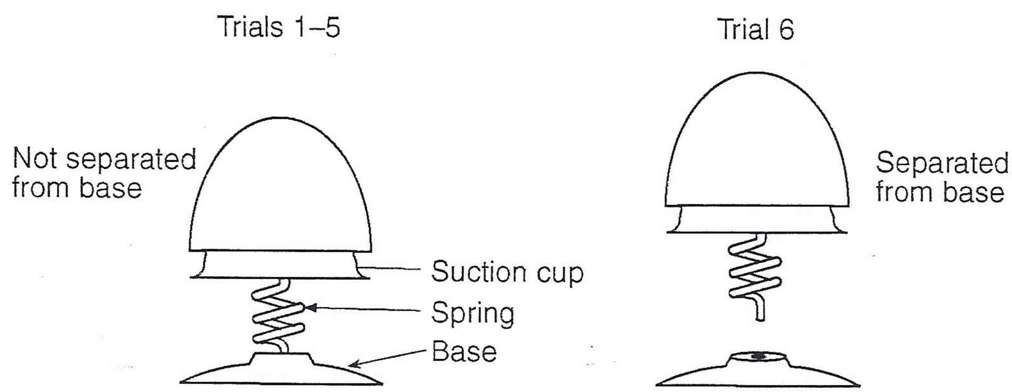
27. Base your answer to the following question on the information below and on your knowledge of physics.

Using a spring toy like the one shown in the diagram, a physics teacher pushes on the toy, compressing the spring, causing the suction cup to stick to the base of the toy.

When the teacher removes her hand, the toy pops straight up and just brushes against the ceiling. She does this demonstration five times, always with the same result.

When the teacher repeats the demonstration for the sixth time the toy crashes against the ceiling with considerable force. The students notice that in this trial, the spring and toy separated from the base at the moment the spring released.

The teacher puts the toy back together, repeats the demonstration and the toy once again just brushes against the ceiling.



Describe the conversions that take place between pairs of the three forms of mechanical energy, beginning with the work done by the teacher on the toy and ending with the form(s) of energy possessed by the toy as it hits the ceiling. [Neglect friction.]

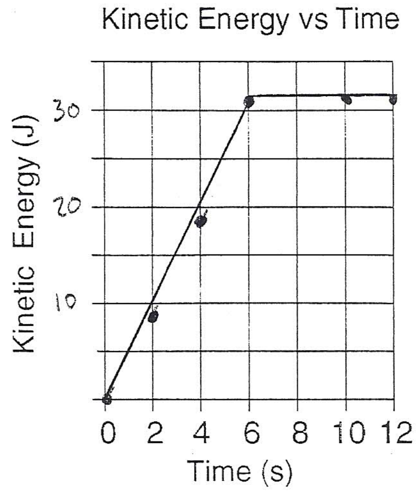
The toy starts with elastic potential energy as a result of work done by the teacher when he/she compresses the toy.

The elastic potential energy is converted to kinetic energy at the moment it leaves the lab table. The kinetic energy is then converted into gravitational potential energy as the height increases. At the moment it hit the ceiling, the toy had both gravitational and kinetic energy.

Base your answers to questions 28 through 30 on the information and table below.

The table lists the kinetic energy of a 4.0-kilogram mass as it travels in a straight line for 12.0 seconds.

Time (seconds)	Kinetic Energy (joules)
0.0	0.0
2.0	8.0
4.0	18
6.0	32
10.0	32
12.0	32



28. Compare the speed of the mass at 6.0 seconds to the speed of the mass at 10.0 seconds.

The speed is constant from 6s — 10s

29. Calculate the speed of the mass at 10.0 seconds. [Show all work, including the equation and substitution with units.]

$KE = \frac{1}{2}mv^2 \longrightarrow v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(32\,J)}{(4.0\,kg)}} = 4\ m/s$

30. *a* Mark an appropriate scale on the axis labeled "Kinetic Energy (J)."
b Plot the data points for kinetic energy versus time.

Base your answers to questions 31 and 32 on the information and diagram below.

A 160.-newton box sits on a 10.-meter-long frictionless plane inclined at an angle of 30.° to the horizontal as shown. Force (F) applied to a rope attached to the box causes the box to move with a constant speed up the incline.

$F_{net} = 0;\ a = 0$

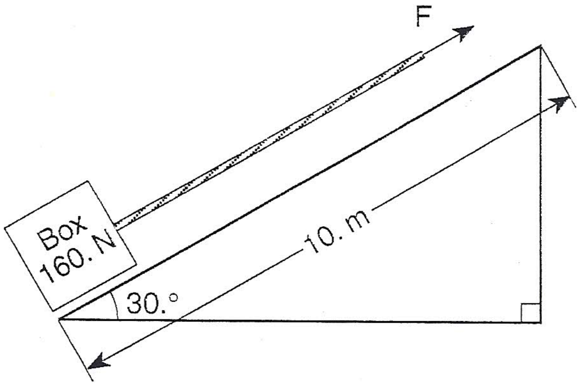
$F = F_g \sin\theta$

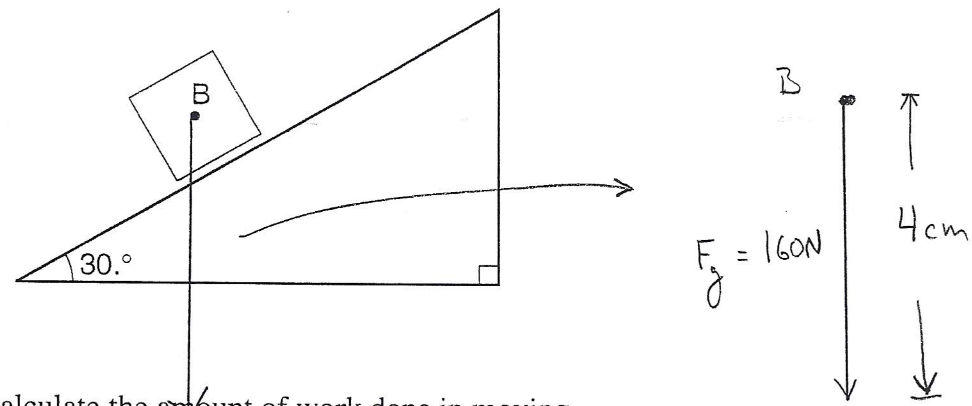
$W = F \cdot d$

$= F_g \sin\theta \cdot d$

$= (160\text{N})(\sin 30°)(10\text{m})$

$= 800\text{ J}$

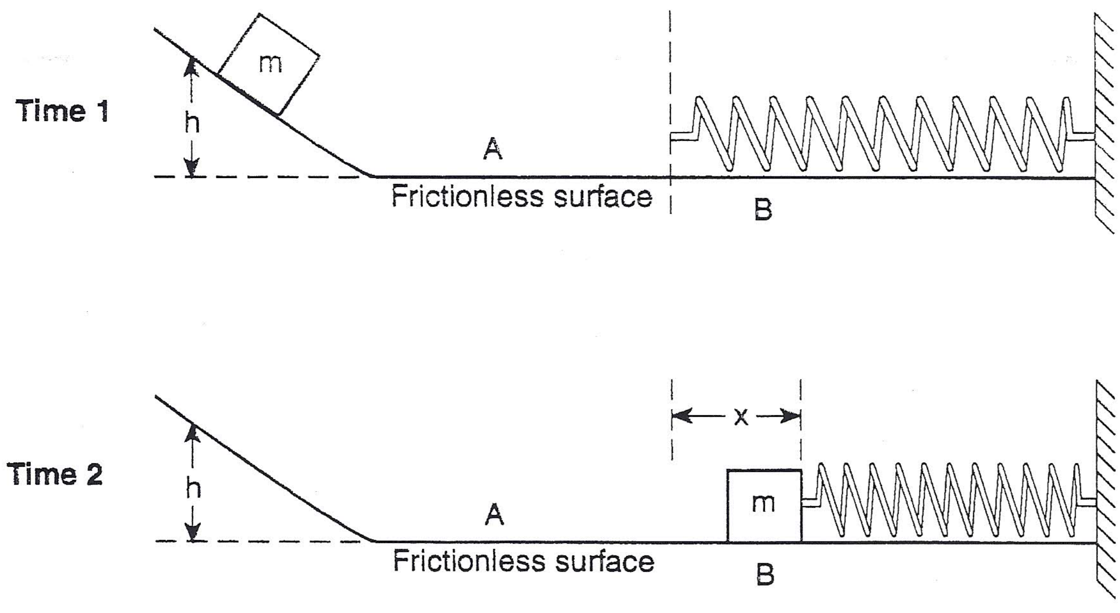




31. Calculate the amount of work done in moving the box from the bottom to the top of the inclined plane. [Show all work, including the equation and substitution with units.]
32. On the diagram above, construct a vector to represent the weight of the box. Use a metric ruler and a scale of 1.0 centimeter = 40. newtons. Begin the vector at point B and label its magnitude in newtons.

Base your answers to questions 33 and 34 on the information and diagram below.

A block of mass *m* starts from rest at height *h* on a frictionless incline. The block slides down the incline across a frictionless level surface and comes to rest by compressing a spring through distance *x*, as shown in the diagram below.



33. Determine the spring constant, *k*, in terms of *g*, *h*, *m*, and *x*. [Show all work including formulas and an algebraic solution for *k*.]

34. Name the forms of mechanical energy possessed by the system when the block is in position *A* and in position *B*.

At position A, the block has kinetic energy
At position B, the block has elastic potential energy.

Using conservation of energy;

$$PE_i = KE_f = PE_s$$

$$PE_i = PE_s$$

$$mg\Delta h = \frac{1}{2}kx^2$$

$$k = \frac{2mg\Delta h}{x^2}$$

Base your answers to questions 35 and 36 on the information below.

A student conducted a series of experiments to investigate the effect of mass, length, and amplitude (angle of release) on a simple pendulum. The table below shows the initial conditions for a series of trials.

Trial	Mass (kg)	Length (m)	Angle of release (°)
R	2	3	10. ✓
S	3	2	15
T	3	2	10.
U	1	3	10. ✓
V	3	2	5
W	2	2	15
X	2	1	15
Y	3	3	10. ✓
Z	2	3	15

35. Which three trials should the student use to test the effect of length on the period of the pendulum?

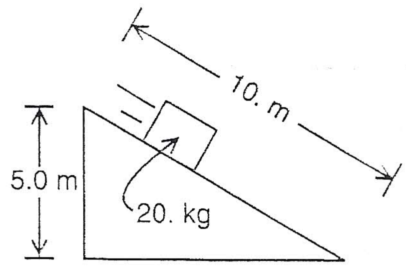
W, X and Z because mass and angle of release are constant while length changes

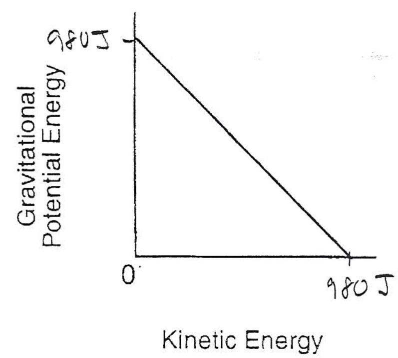
36. Which three trials should the student use to test the effect of mass on the period of the pendulum?

R, U, Y

Base your answers to questions 37 through 39 on the information and diagram below.

A 20.-kilogram block is placed at the top of a 10.-meter-long inclined plane. The block starts from rest and slides without friction down the length of the incline.





37. On the axes provided above, sketch a graph of the gravitational potential energy of the block as a function of its kinetic energy for the complete slide. Label your graph with appropriate values and units.

38. Determine the gravitational potential energy of the block at the top of the incline. [Show all calculations, including the equation and substitution with units.]

$PE = mg\Delta h = (20.\ kg)(9.81\ m/s^2)(5.0\ m) = 980\ J$

39. Determine the kinetic energy of the block just as it reaches the bottom of the incline.

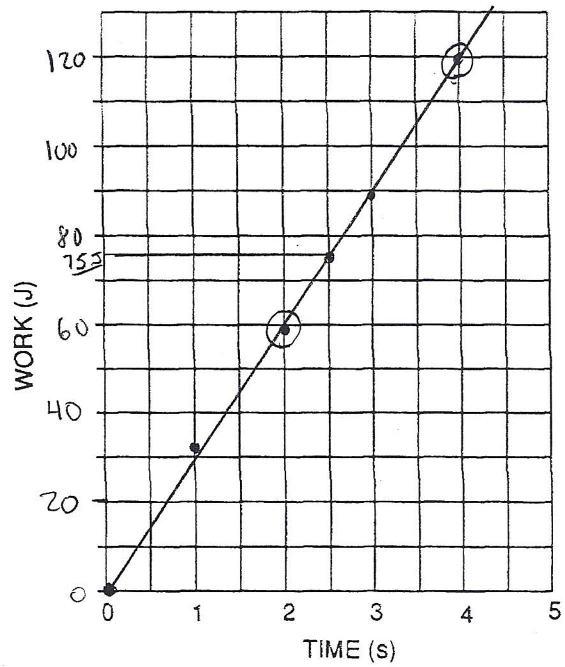
$PE = KE = 980\ J$

40. Base your answers to parts *a* through *c* on the information below.

A student performs a laboratory activity in which a 15-newton force acts on a 2.0-kilogram mass. The work done over time is summarized in the table below.

DATA TABLE

Time (s)	Work (J)
0	0
1.0	32
2.0	59
3.0	89
4.0	120



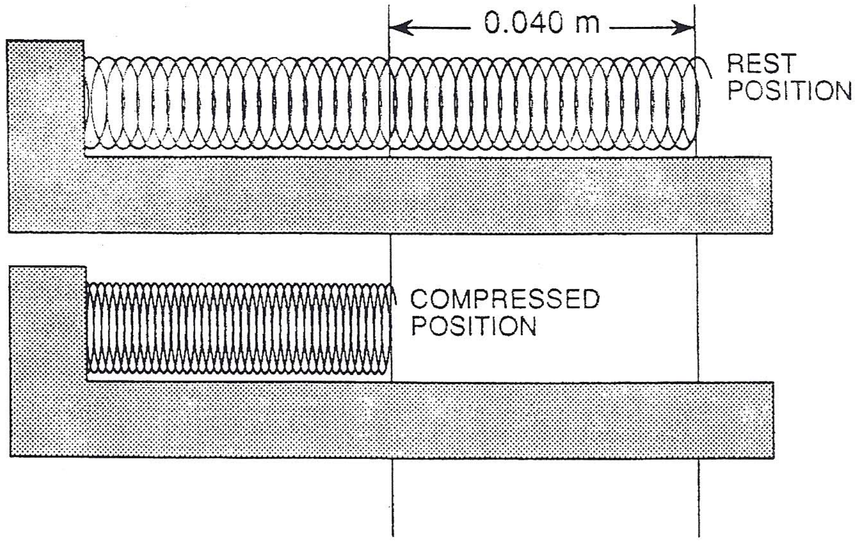
a Using the information in the data table, construct a graph on the grid provided, following the directions below.
(1) Develop an appropriate scale for work, and plot the points for a work-versus-time graph,
(2) Draw the best-fit line.

b Calculate the value of the slope of the graph constructed in part a. (Show all calculations, including equations and substitutions with units.)

c Based on your graph, how much time did it take to do 75 joules of work? 2.5s

Slope: $m = \frac{\Delta y}{\Delta x} = \frac{120J - 60J}{4.0s - 2.0s} = 30W$

41. The diagram below shows a spring compressed by a force of 6.0 Newtons from its rest position to its compressed position.



Calculate the spring constant for this spring. [Show all calculations, including equations and substitutions with units.]

$F_s = kx$

$k = \frac{F_s}{x} = \frac{6.0\,N}{0.04\,m} = 150\,N/m$

42. Base your answer to parts *a* through *d* on the information below.

A 6.0-kilogram concrete block is dropped from the top of a tall building. The block has fallen a distance of 55 meters and has a speed of 30. meters per second when it hits the ground.

a At the instant the block was released, what was its gravitational potential energy with respect to the ground? [Show all calculations, including the equation and substitution with units.]

b Calculate the kinetic energy of the block at the point of impact. [Show all calculations, including the equation and substitution with units.]

c How much mechanical energy was "lost" by the block as it fell?

d Using one or more complete sentences, explain what happened to the mechanical energy that was "lost" by the block.

a) $PE_i = mg\Delta h = (6.0\,kg)(9.81\,m/s^2)(55\,m) = 3240\,J$

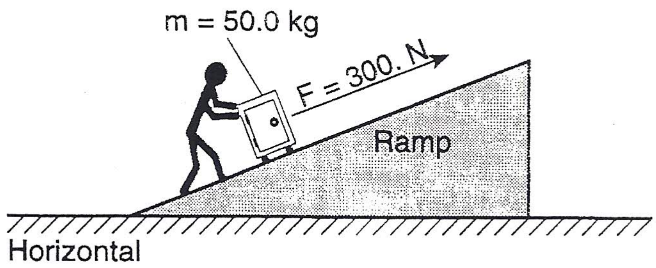
b) $KE_f = \frac{1}{2}mv^2 = (\frac{1}{2})(6.0\,kg)(30\,m/s)^2 = 2700\,J$

c) $PE_i - KE_f = Q \longrightarrow 540\,J$

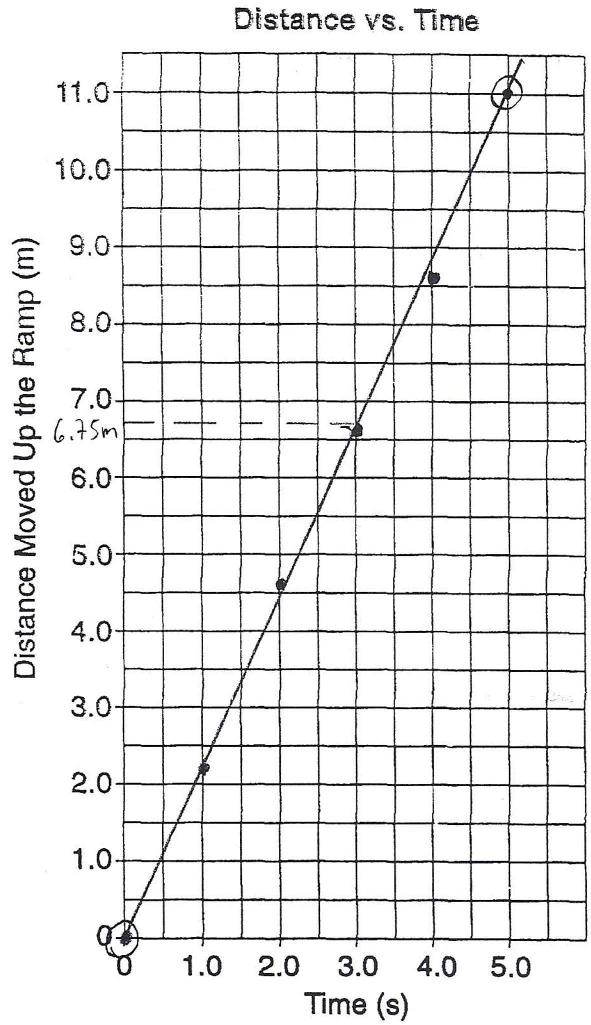
d) The mechanical energy was lost due to friction with the atmosphere.

Base your answers to questions 43 through 45 on the diagram and data table below.

The diagram shows a worker moving a 50.0 kilogram safe up a ramp by applying a constant force of 300. Newtons parallel to the ramp. The data table shows the position of the safe as a function of time.



Time (s)	Distance Moved up the Ramp (m)
0.0	0.0
1.0	2.2
2.0	4.6
3.0	6.6
4.0	8.6
5.0	11.0



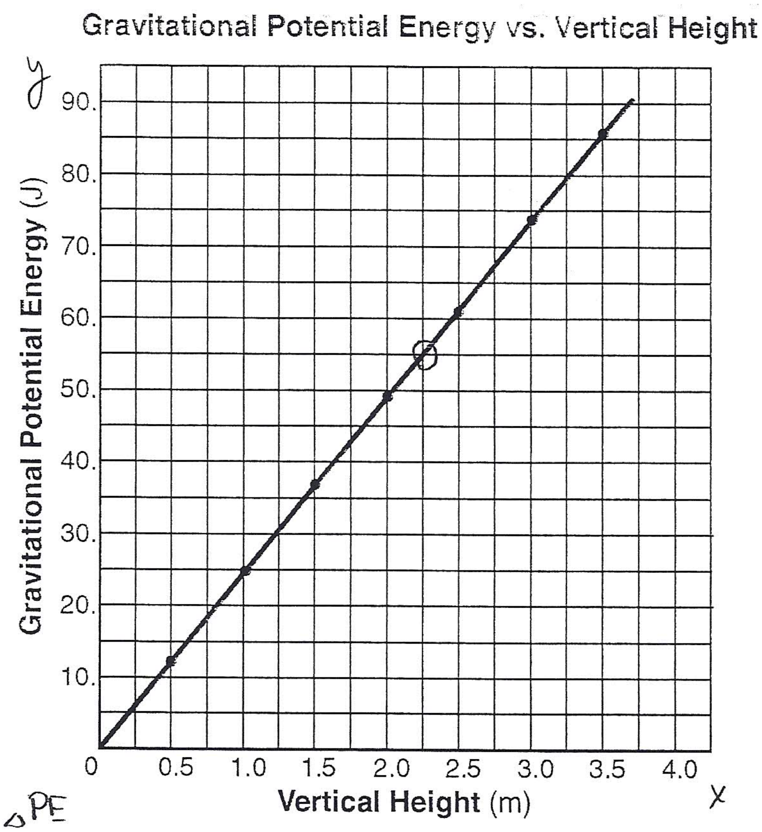
43. Calculate the work done by the worker in the first 3.0 seconds. [Show all calculations, including the equation and substitution with units.]

$W = F \cdot d = (300N)(6.75m) = 2025J$

44. Using the information in the data table, construct a line graph on the grid. Then draw data points and draw the best-fit line.

45. Using one or more complete sentences, explain the physical significance of the slope of the graph.

Base your answers to questions **46** and **47** on the graph below, which represents the relationship between vertical height and gravitational potential energy for an object near Earth's surface.



Slope = $\frac{\Delta y}{\Delta x} = \frac{\Delta PE}{\Delta h}$

46. What physical quantity does the slope of the graph represent?

$PE = mg\Delta h \longrightarrow \frac{PE}{\Delta h} = mg \longrightarrow mg = F_g \longrightarrow$ Weight.

47. Using the graph, calculate the mass of the object. [Show all work, including the equation and substitution with units.]

$F_g = \frac{55\,J - 0\,J}{2.25m - 0m} = 22N$

$F_g = mg$

$m = F_g / g = 22N / 9.81 m/s^2 = 2.24\,kg$