Name:

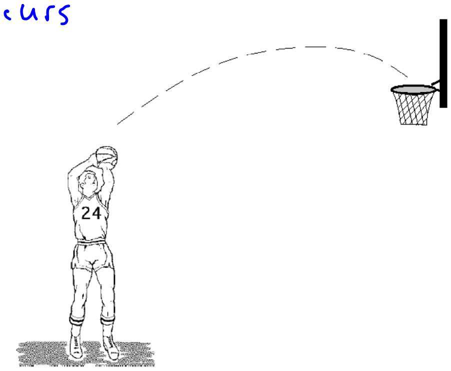
The Ultimate Work/Energy/Power Assignment

9406

1.

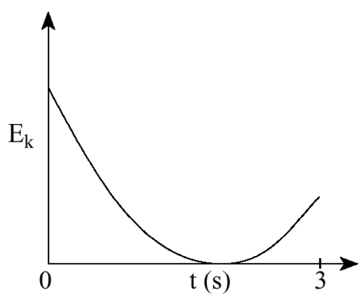
A basketball is thrown into the basket, as shown in the diagram below. The ball leaves the player hand at t= 0 s and reaches the basket at t = 3 s.

slowest velocity occurs at the top, but never hits zero

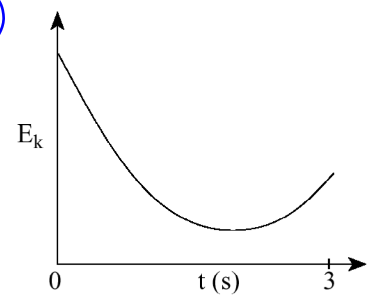


Which of the following graphs **best** represents the ball's kinetic energy E_k as a function of time?

A.



B.



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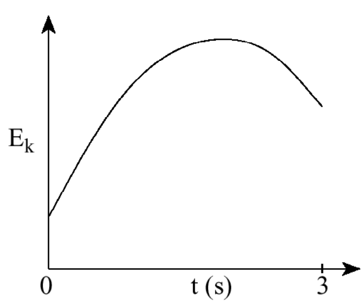

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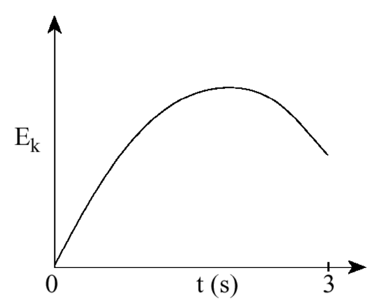


9501

2.

How much work must be done to stop an 1 800 kg vehicle travelling at 30 m/s?

$W = \Delta KE = KE_f - KE_i$

$= \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$= 0 - \frac{1}{2}(1800)(30)^2$

A. 1.8×10^4 J

B. 5.4×10^4 J

C. 5.3×10^5 J

D. 8.1×10^5 J

9506

3.

Work is measured in which units?

A. J

B. N

C. J/s

D. $N \cdot s$

4.

What is the minimum power developed by a 75 kg person who climbs a set of stairs 4.5 m high in 5.0 s?

$P = \frac{W}{t} = \frac{(75)(9.8)(4.5)}{5} = 662$ W

A. 6.8×10^1 W

B. 6.6×10^2 W

C. 1.7×10^3 W

D. 3.3×10^3 W

5.

A 3.5 kg projectile was launched vertically at 75 m/s. The projectile reached a maximum height of 180 m. How much energy was lost to heat while the projectile was rising?

A. 0 J

B. 3.7×10^3 J

C. 6.2×10^3 J

D. 9.8×10^3 J

$KE_i + PE_i = KE_f + PE_f + \text{heat}$

$\frac{1}{2} m v_i^2 + 0 = 0 + mgh_f + \text{heat}$

$\text{heat} = \frac{1}{2} m v_i^2 - mgh_f = \frac{1}{2}(3.5)(75)^2 - 3.5(9.8)(180)$

$= 3.7 \times 10^3$ J

9606
6.
As a skier descends a slope, her kinetic energy increases from 600 J to 3 200 J while her gravitational potential energy decreases by 5 900 J. How much heat energy is created due to friction?

$\Delta PE = 5900$ $\Delta KE = 2600$

A. 2 100 J
B. 3 300 J
C. 8 500 J
D. 9 700 J

the difference is heat

$5900 - 2600$

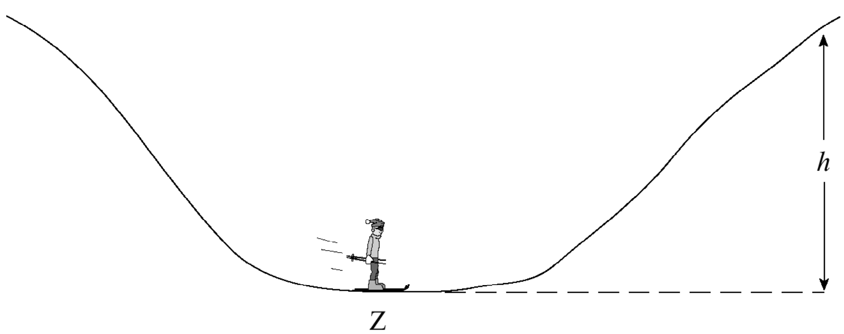
9608
7.
Calculate the minimum power of a cyclist who can increase his kinetic energy from 480 J to 2 430 J by travelling 26 m in 4.0 s.

$W = \Delta KE = 2430 - 480 = 1950$

A. 75 W
B. 3.6×10^2 W
C. 4.9×10^2 W
D. 7.3×10^2 W

$P = \frac{W}{t} = \frac{1950}{4} = 488$ W

9706
8.
René, whose mass is 85 kg, skis down the hill, passing Z with a kinetic energy of 9 700 J.



If friction is ignored, to what maximum height, h, can René ski?

A. 12 m
B. 15 m
C. 1.1×10^2 m
D. 6.6×10^2 m

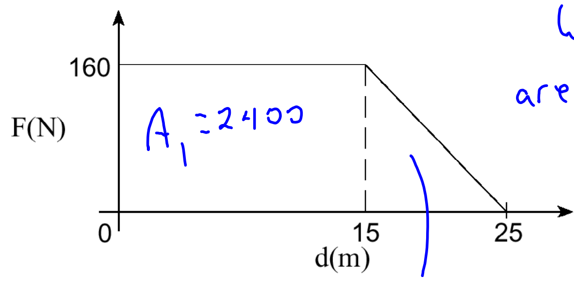
$\Delta KE = \Delta PE$

$9700 = mgh$

$h = \frac{9700}{(85)(9.8)} = 11.6$ m

9.

A cyclist travelling at 10 m/s applies her brakes and stops in 25 m. The graph shows the magnitude of the braking force versus the distance travelled.



$W = \Delta KE$

area $= KE_f - KE_i$

$= 0$

What is the total mass of bike and cyclist?

A. 20 kg
B. ~~40 kg~~
C. 64 kg
D. 80 kg

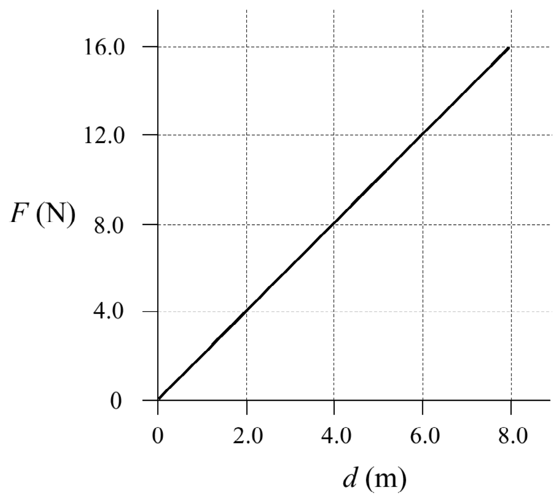
$3200 = \frac{1}{2} m v_i^2$

$\frac{3200}{.5(10)^2} = m$

$m = 64$ kg

9708
10.

The graph below shows the relationship between the force applied and the distance moved for a 3.5 kg object on a frictionless horizontal surface.



$W = \Delta KE$

area $= KE_f - KE_i$

$\frac{(16)(8)}{2} = 64$ J

If the object was initially at rest, what is its kinetic energy after travelling 8.0 m?

A. 2.0 J
B. 32 J
C. 64 J
D. 130 J

9801
11.

Which of the following is a definition of power?

A. Power is the rate of change of flux.
B. Power is the rate of change of energy.
C. Power is the rate of change of momentum.
D. Power is the rate of change of displacement.

9806
12.

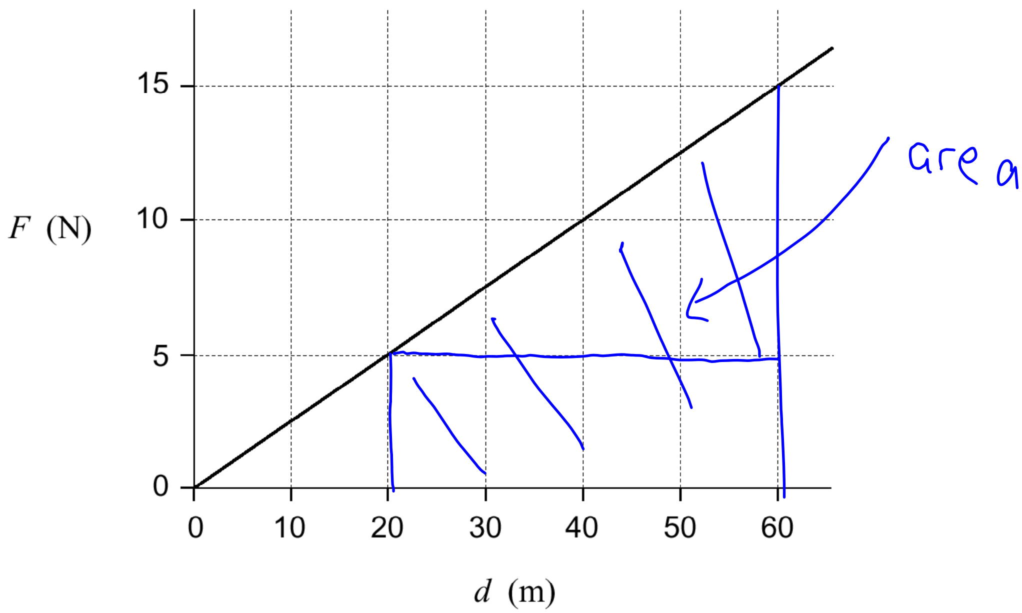
The graph below shows how the force acting on an object varies with distance

$W = \text{Area}$

$= 40 \times 5 + \frac{(40)(10)}{2}$

$= 200 + 200$

$= 400\ J$

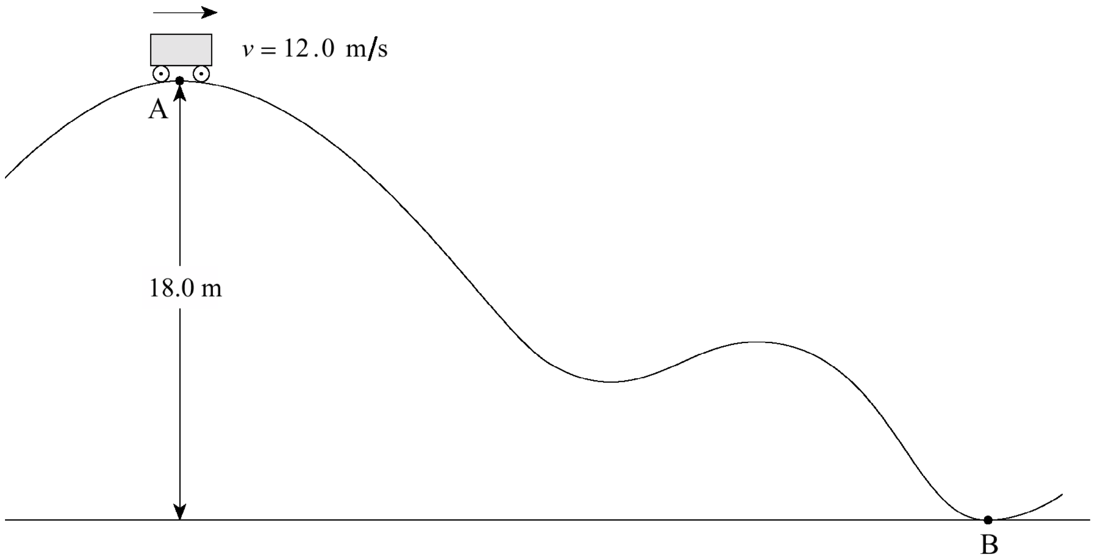


What is the work done in moving the object from 20 m to 60 m?

A. 50 J
B. 100 J
C. 400 J
D. 900 J

13.

A 250 kg roller coaster passes point A at 12.0 m/s.



What is the speed of the roller coaster at point B at the bottom of the hill if 8 500 J of energy is transformed to heat during the journey? **(7 marks)**

$KE_i + PE_i = KE_f + \underbrace{\cancel{PE_f}}_{=0} + heat$

$\frac{1}{2}mv_i^2 + mgh_i - heat = \frac{1}{2}mv_f^2$

$\frac{1}{2}(250)(12)^2 + (250)(9.8)(18) - 8500 = \frac{1}{2}(250)v_f^2$

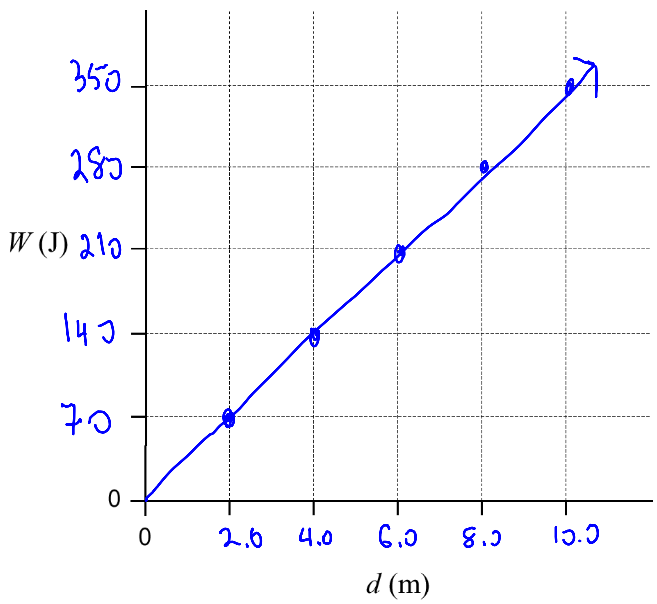
$v_f = \sqrt{\dfrac{\frac{1}{2}(250)(12)^2 + (250)(9.8)(18) - 8500}{125}}$

$v_f = 20.7$ m/s

14.
A gardener does work W pushing a lawnmower a distance d across a lawn.

W (J)	70	140	210	280	350
d (m)	2.0	4.0	6.0	8.0	10.0

a) Plot a graph of W versus d on the axes below. **(2 marks)**



b) Calculate the slope of the line, expressing your answer in appropriate units. **(2 marks)**

slope $= \dfrac{\text{rise}}{\text{run}} = \dfrac{350}{10} = 35 \dfrac{\text{J}}{\text{m}}$ or 35 N

c) What does the slope of the line represent? **(1 mark)**

force required to push lawnmower

9808

15.

A $0.030\ \text{kg}$ toy car is pushed back against a spring-based launcher as shown in Diagram 1.

Diagram 1

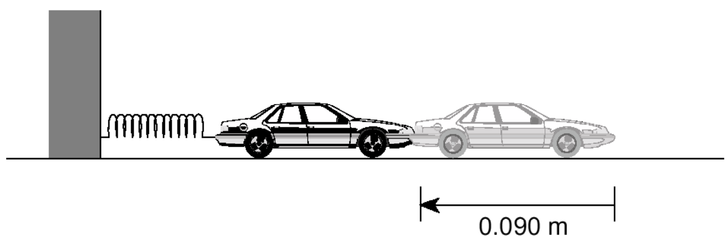
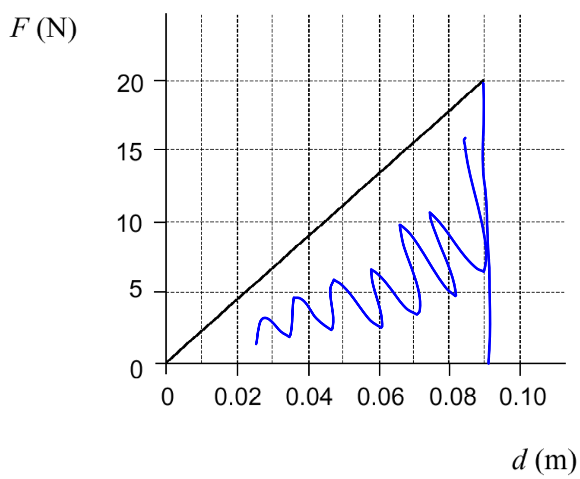


Diagram 2 shows a graph of the force required to compress the spring $0.090\ \text{m}$.

Diagram 2



a) Work = area under graph

$$= \frac{(.09)(20)}{2} = .90\ \text{J}$$

a) What is the work done in compressing the spring? **(3 marks)**

b) Assuming no losses due to heat, what maximum speed is reached by the toy car when it is released? **(3 marks)**

c) If in fact the maximum kinetic energy of the car is $0.18\ \text{J}$, what is the efficiency of the spring-based launcher? **(1 mark)**

b) $W = \Delta KE = \frac{1}{2}mv_f^2 - \cancel{\frac{1}{2}mv_i^2}$ $=0$

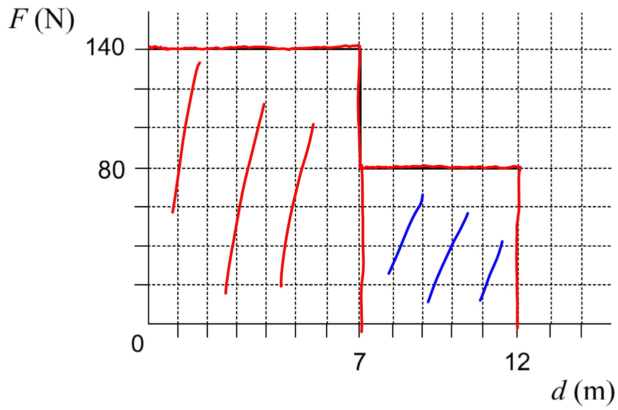
$$W = \frac{1}{2}mv_f^2 \rightarrow v_f = \sqrt{\frac{2W}{m}} = \sqrt{\frac{2(.9)}{.03}} = 7.7\ \text{m/s}$$

c) $$\text{eff} = \frac{E_{out}}{E_{in}} = \frac{0.18}{0.90} \times 100 = 20\%$$

9901

16.

Starting from rest, a farmer pushed a cart 12 m. The graph shows the force *F* which he applied, plotted against the distance *d*.



a) $W = \text{area}$

$= (140)(7) + (80)(5)$

$= 1.38 \times 10^{3}$ J

a) How much work did the farmer do moving the cart 12 m? **(3 marks)**

b) After the farmer had pushed the 240 kg cart 12 m, it was moving with a velocity of 2.2 m/s. What was the cart's kinetic energy? **(2 marks)**

c) What was the efficiency of this process? **(2 marks)**

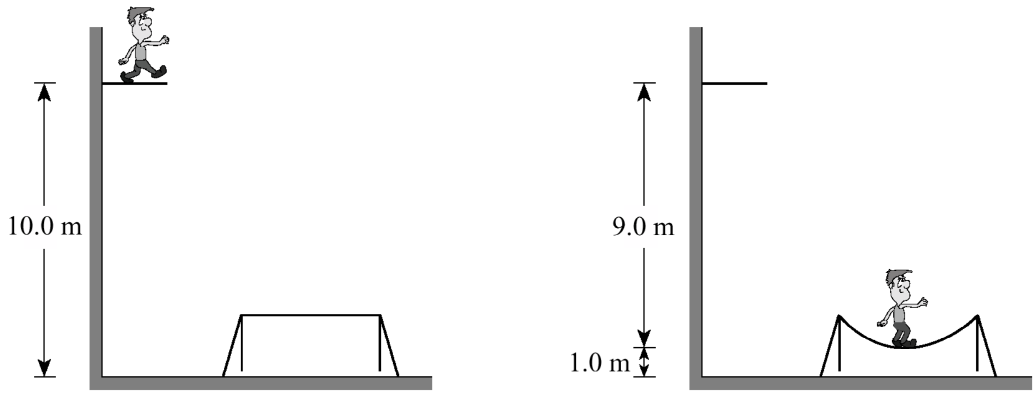
b) $KE = \frac{1}{2}mv^2 = \frac{1}{2}(240)(2.2)^2 = 581$ J

c) $\text{eff} = \frac{W_{out}}{W_{in}} = \frac{580.8}{1380} \times 100 = 42\,\%$

0008

17.

A 55.0 kg athlete steps off a 10.0 m high platform and drops onto a trampoline. As the trampoline stretches, it brings him to a stop 1.00 m above the ground.



How much energy must have been momentarily stored in the trampoline when he came to rest?

A. 0 J
B. 539 J
C. 4 850 J
D. 5 390 J

all of his gravitational PE is stored in tramp.

$\therefore\ mgh = 55(9)(9.8) = 4.85\times10^{3}\ J$

not 10!

18.

An object starts from rest and slides down a frictionless track as shown. It leaves the track horizontally, striking the ground at a distance *d* as shown.

hmm... $d_x = v_x t$

What is v_x?

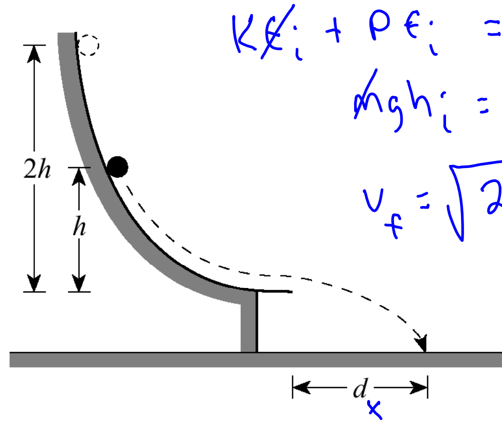
(t will be constant)

$KE_i + PE_i = KE_f + PE_f$

$mgh_i = \frac{1}{2} m v_f^2$

$v_f = \sqrt{2gh}$

this is v_f. what if we double h?



The same object is now released from twice the height, 2*h*. How far away will it land?

A. *d*
B. $\sqrt{2}\ d$
C. 2*d*
D. 4*d*

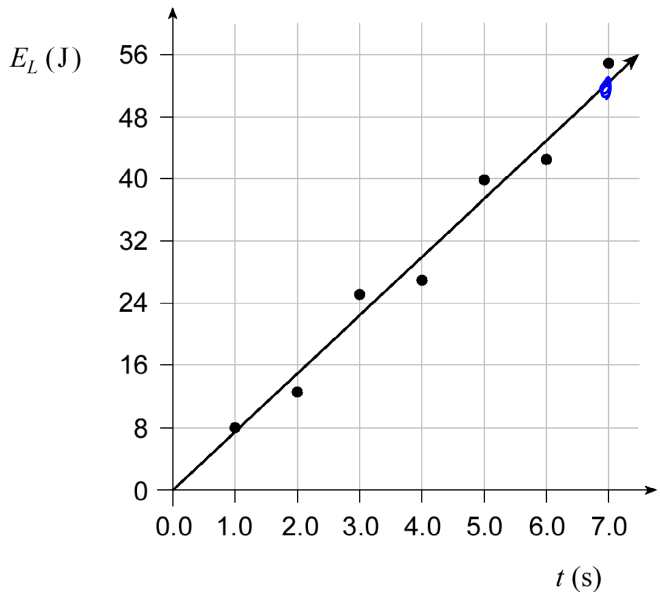
$v_f = \sqrt{2g(2h)} = \sqrt{2}\cdot\sqrt{2gh}$

$= \sqrt{2}\ v_f$

$\therefore$ doubling h increases v_f by a factor of $\sqrt{2}$

19.

The graph shows the light energy E_L emitted by a bulb versus time t.



a) Find the power output of the bulb. **(2 marks)**

b) If this bulb is 20% efficient, find the power delivered to the bulb. **(3 marks)**

a) $P = \frac{W}{t} = \frac{\text{Energy}}{t} = $ slope of graph!

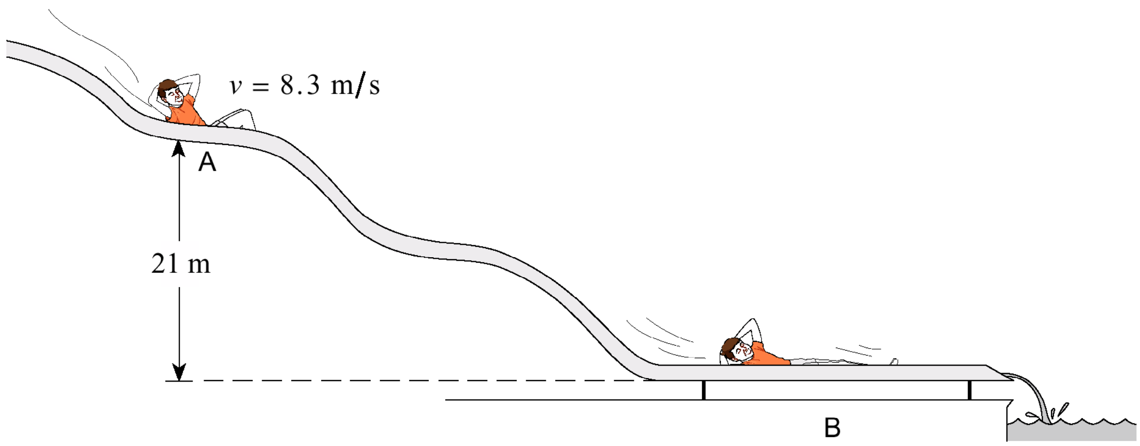
$\text{slope} = \frac{\text{rise}}{\text{run}} \approx \frac{52}{7} \approx 7.4 \text{ W}$

b) $\text{eff} = \frac{P_{out}}{P_{in}} \rightarrow .20 = \frac{7.4}{P_{in}} \rightarrow P_{in} \approx 37 \text{ W}$

9906

20.

A 45 kg child on a water slide passes point A at 8.3 m/s.



As the child descends from A to B, 3 600 J of heat energy is created because of friction. What is his speed at B? **(7 marks)**

$$KE_i + PE_i = KE_f + \cancel{PE_f} + heat$$

$$\frac{1}{2}mv_i^2 + mgh_i - heat = \frac{1}{2}mv_f^2$$

$$v_f = \sqrt{\frac{\frac{1}{2}mv_i^2 + mgh_i - heat}{\frac{1}{2}m}}$$

$$v_f = \sqrt{\frac{\frac{1}{2}(45)(8.3)^2 + 45(9.8)(21) - 3600}{\frac{1}{2}(45)}}$$

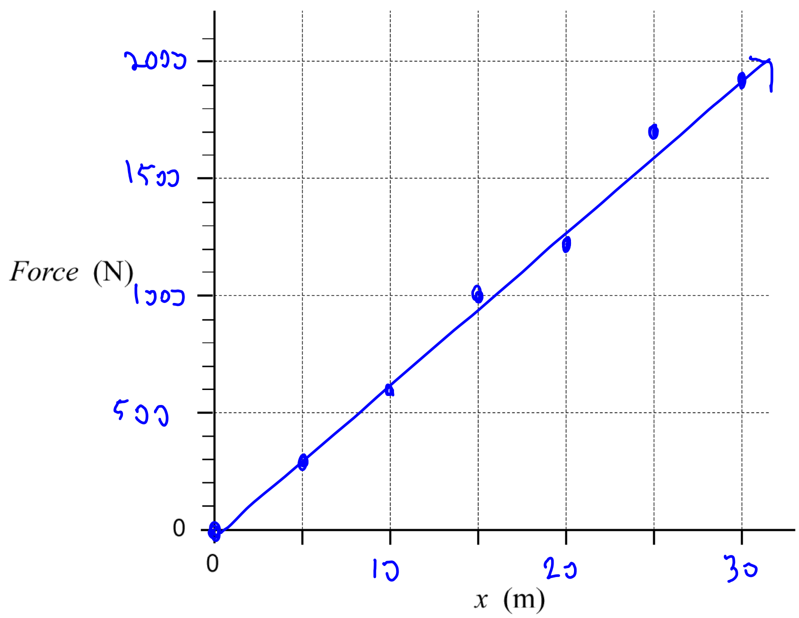
$$v_f = 17.9 \text{ m/s}$$

21.

A daredevil is attached by his ankles to a bungee cord and drops from the top of a bridge. The force exerted on the daredevil by the bungee cord is measured against the change in length, x, of the cord as the cord is stretched, slowing the daredevil's fall.

Force (N)	0	300	600	1 000	1 200	1 700	1 900
x (m)	0	5	10	15	20	25	30

a) Plot a graph of force vs. change in length on the graph below. **(2 marks)**



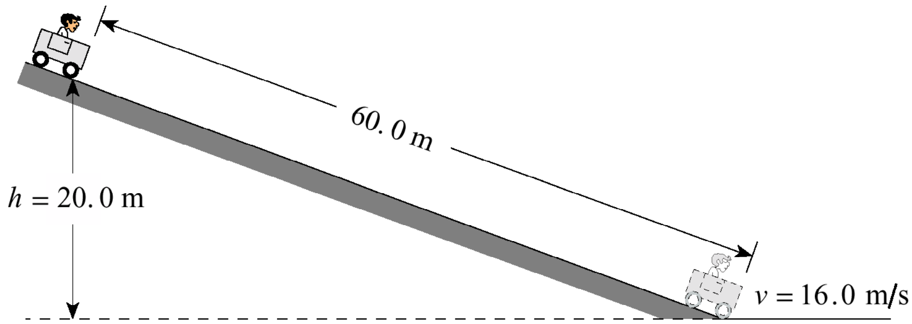
b) Use the graph to determine the work done by the bungee cord during its stretch. **(3 marks)**

$W = \text{area} = \frac{1}{2}(30)(1900) = 2.85 \times 10^4$ J

0001

22.

A 170 kg cart and rider start from rest on a 20.0 m high incline.



a) How much energy is transformed to heat? **(5 marks)**

b) What is the average force of friction acting on the cart? **(2 marks)**

a) $KE_i + PE_i = KE_f + \cancel{PE_f} + heat$

$KE_i + PE_i - KE_f = heat$

$\frac{1}{2}mv_i^2 + mgh_i - \frac{1}{2}mv_f^2 = heat$

$heat = 1.16 \times 10^4 \text{ J}$

b) $W = F \times d$

$heat = F_{fr} \times d_{ramp}$

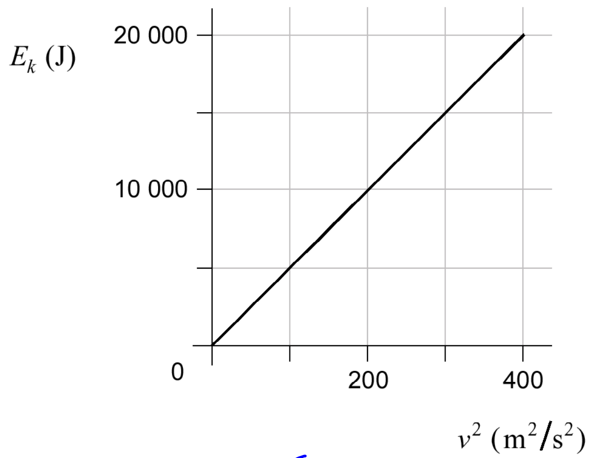
oh! So that's why they told me how long the ramp was!

$$F_{fr} = \frac{heat}{d_{ramp}} = \frac{1.16 \times 10^4}{60} = 193 \text{ N}$$

0006

23.

A student plots the graph below, showing the kinetic energy E_k of a motorbike versus the square of its velocity v^2.



a) slope $= \frac{20,000}{400}$

$= 50$

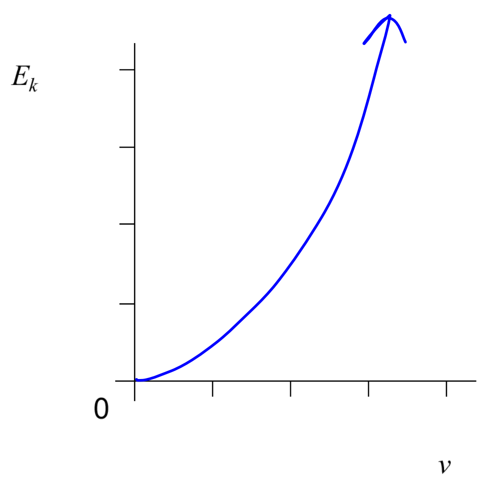
a) What is the slope of this graph? $50 \ J/_{m^2/s^2}$ **(2 marks)**

b) What does the slope represent? **(2 marks)**

hmm... $KE = \frac{1}{2}mv^2$ $\therefore$ $\frac{KE}{v^2} = \frac{1}{2}m$

$\therefore$ slope is half the mass

c) Using the axes below, sketch the graph of kinetic energy E_k versus velocity v for this motorbike. There is no need to plot any data points. **(1 mark)**



hmm....

$KE = \frac{1}{2}mv^2$

this will be a parabola!

0008

24.

A change in kinetic energy is equivalent to

A. work.
B. power.
C. impulse.
D. momentum.

"Work-Energy Theorem"

25.

A 16 kg object is dropped from a height of 25 m and strikes the ground with a speed of 18 m/s. How much heat energy was produced during the fall?

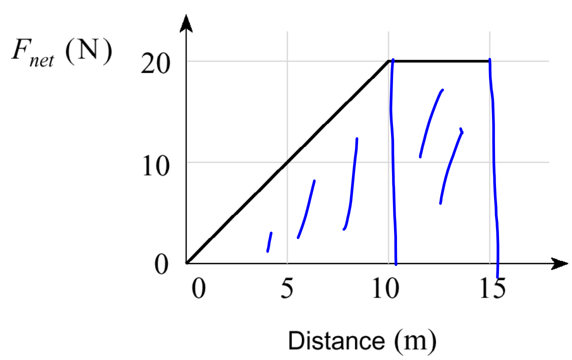
A. 0 J
B. 1 300 J
C. 2 600 J
D. 3 900 J

$\cancel{KE_i} + PE_i = KE_f + \cancel{PE_f} + heat$

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

26.

A force is applied to an 8.0 kg object initially at rest. The magnitude of the net force varies with distance as shown.



$W = \text{area}$

$= \frac{(10)(20)}{2} + (20)(5)$

$= 200\ J$

What is the speed of the object after moving 15 m?

A. 5.0 m/s
B. 6.1 m/s
C. 7.1 m/s
D. 8.7 m/s

$W = \Delta KE$

$200 = KE_f - \cancel{KE_i}$

$200 = \frac{1}{2}mv_f^2$

$v_f = \sqrt{\frac{2(200)}{8}} = 7.1$

27.

A machine rated at 1 500 W lifts a 100 kg object 36 m vertically in 45 s. What is the efficiency of this machine?

$P_{out} = \frac{W}{t} = \frac{mgh}{t} = \frac{(100)(9.8)(36)}{45} = 784\ W$

A. 0.053
B. 0.48
C. 0.52
D. 0.65

$Eff = \frac{784}{1500} \times 100\ \%$

0101
28.

A crane lifts a 3 900 kg shipping container through a vertical height of 45 m in 8.0 s. What is the minimum average power that the crane motor must supply?

$P = \frac{W}{t} = \frac{mgh}{t} = \frac{(3900)(9.8)(45)}{8}$

A. 2.7×10^{3} W
B. 7.7×10^{3} W
C. 2.1×10^{5} W
D. 1.7×10^{6} W

0106
29.

In order to use the joule as a unit of energy in an experiment, measurements must be converted to

A. cm, g and s
B. m, kg and s
C. cm, N and s
D. m, g and min

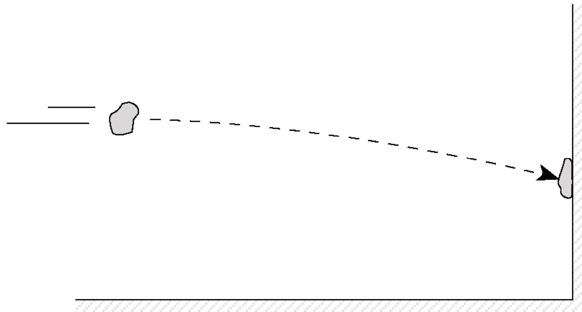
0108
30.

Which of the following best represents efficiency?

A. Final time compared to initial time
B. Work output compared to work input
C. Final velocity compared to initial velocity
D. Momentum after compared to momentum before

31.

A wad of putty is thrown against a wall as shown. The wad of putty sticks against the wall.



Roughly the same h_i as h_f

$\therefore PE_i \approx PE_f$

Which of the following statements best applies the application of the law of conservation of energy to this collision?

$\therefore KE_i$ must become heat

A. All energy has been lost.
B. Kinetic energy is converted to heat.
C. Kinetic energy is converted to momentum.
D. Kinetic energy is converted to potential energy.

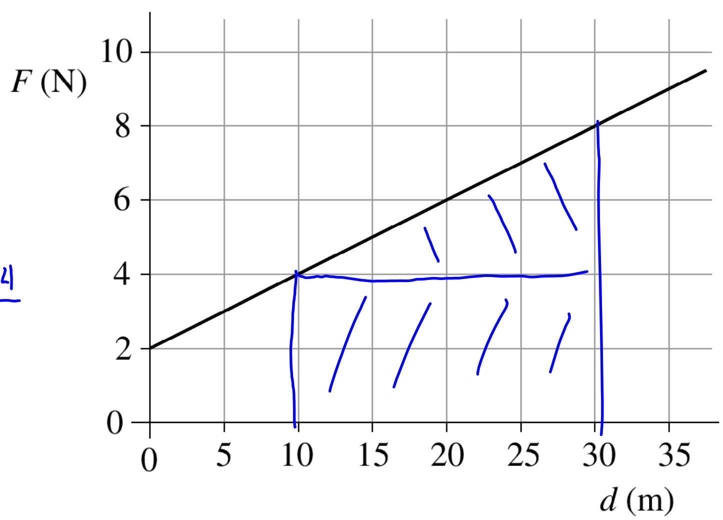
32.

The graph below shows how the force applied to an object varies with distance.

$W = \text{area}$

$= 20 \times 4 + \frac{20 \times 4}{2}$

$= 80 + 40$



What is the work done to move the object from 10 m to 30 m?

A. 40 J
B. 80 J
C. 120 J
D. 240 J

0201

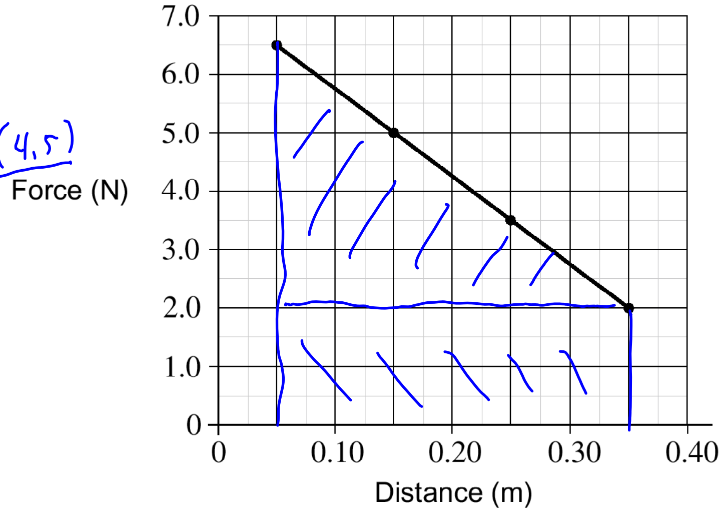
33.

A student records the force used to move a block. The graph of his force and distance data is shown below.

$W = \text{area}$

$= (.3)(2) + \frac{(.3)(4.5)}{2}$

$= 1.275\ J$



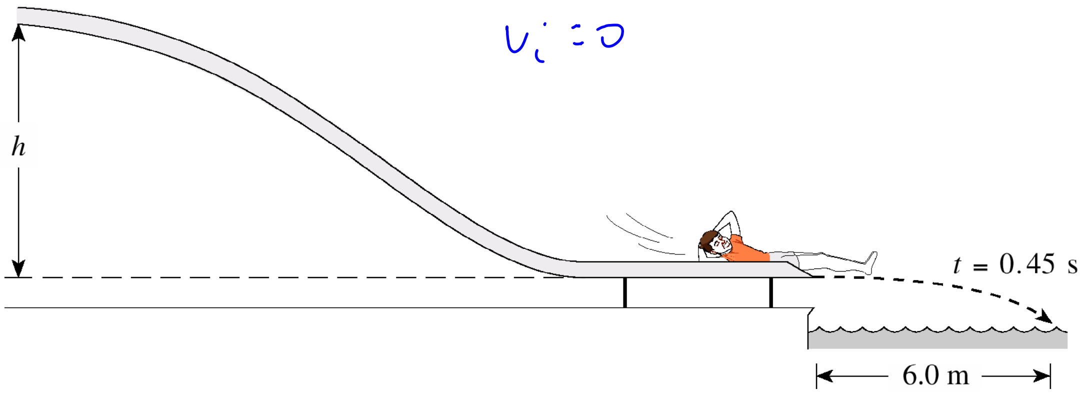
What is the work done in moving the block from 0.050 m to 0.35 m?

A. 0.68 J
B. 0.98 J
C. 1.3 J
D. 2.0 J

34.

A water slide is made so that swimmers, starting from rest at the top, leave the end of the slide travelling horizontally as shown.

$v_i = 0$



One person is observed to hit the water at a horizontal distance of 6.0 m from the end of the slide 0.45 s after leaving the slide. The effects of friction and air resistance are negligible.

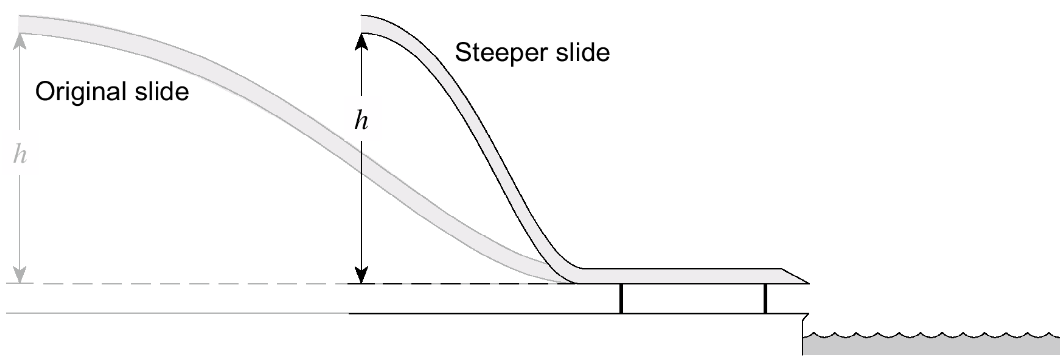
a) From what vertical height, *h*, did the person start? **(5 marks)**

$d_x = v_x t \rightarrow v_x = \frac{d_x}{t} = \frac{6}{.45} = 13.33 \text{ m/s}$ this is v_f

$\cancel{KE_i} + PE_i = KE_f + \cancel{PE_f}$

$\cancel{m}gh_i = \frac{1}{2}\cancel{m}v_f^2 \rightarrow h_i = \frac{v_f^2}{2g} = 9.1 \text{ m}$

b) Another slide has the same vertical height, *h*, as the original slide, but has a much steeper slide angle.



The same person is observed to go down this steep slide. Using principles of physics, explain how the new horizontal distance from the edge of the slide compares with the first situation. The effects of friction and air resistance are negligible. **(4 marks)**

Same d_x, since v_f will be the same, since energy is a scalar, so the path is irrelevant.

0208

35.

A 1500 kg car moving at 8.0 m/s comes to a stop in 16 m when its brakes are applied. The speed of the car is now doubled to 16 m/s. Assuming the same braking force as before, how far will the car travel before coming to a stop?

A. 16 m
B. 32 m
C. 64 m
D. 130 m

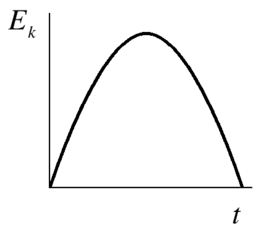
double speed = 4 times as much KE

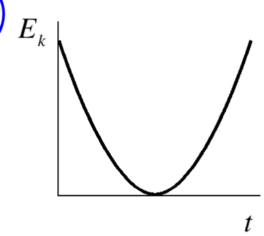
∴ 4 times as long to stop

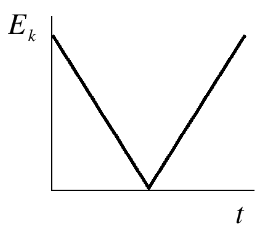
0301

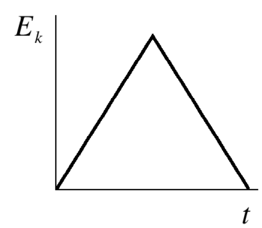
36.

A rock is thrown straight up. Which of the following represents the kinetic energy versus time graph of the rock while it is in the air?

A.


B.


C.


D.


37.

What minimum force applied over a distance of 35.0 m would be needed to accelerate a 925 kg car from rest to 13.9 m/s?

A. 367 N
B. 2550 N
C. 12 900 N
D. 89 400 N

$W = F \times d \rightarrow F = \frac{W}{d}$

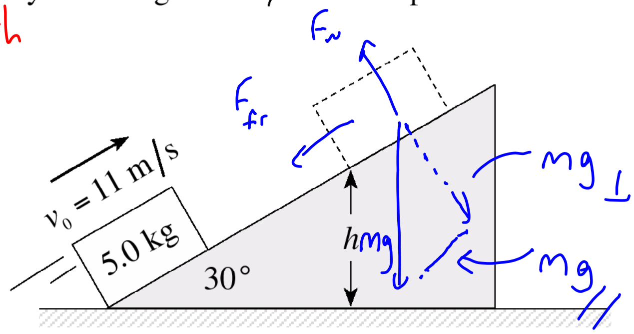
$W = \Delta KE = \frac{1}{2} m v_f^2 - \cancel{\frac{1}{2} m v_i^2}$ $= 0$

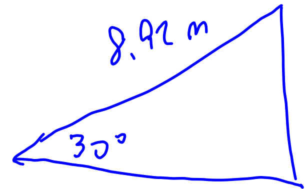
$F = \frac{\frac{1}{2} m v_f^2}{d} = \frac{\frac{1}{2}(925)(13.9)^2}{35} = 2553 \text{ N}$

38.

A 5.0 kg block initially travelling at 11 m/s moves up a 30° incline as shown.

I solved this with forces. You could also solve this with energy!





$\boxed{h = 4.5\ m}$

A frictional force of 9.4 N acts on the block as it moves up the incline. What maximum vertical height, *h*, will the block reach?

A. 4.5 m
B. 5.2 m
C. 6.2 m
D. 6.7 m

$mg_{\parallel} + F_{fr} = ma$

$\frac{mg \sin 30 + 9.4}{m} = a$

$a = 6.78\ m/s^2$

$d = \frac{\cancel{v_f^2} - v_i^2}{2a}$

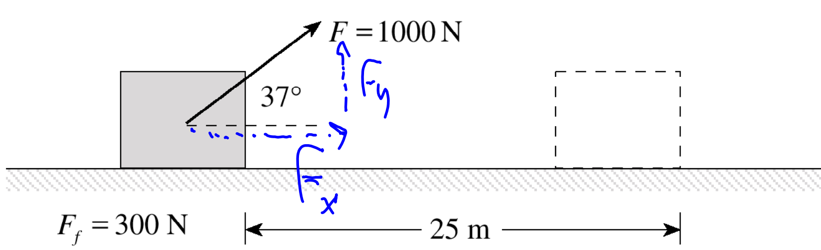
0

$d = 8.92\ m$

0306

39.

A 1000 N force is applied to a block as shown. There is 300 N of sliding friction as the block moves 25 m along the surface.



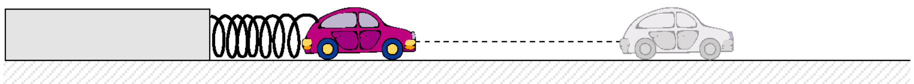
Force and distance must be in same direction!

How much work was done by the applied force in moving this block?

A. 1.5×10^4 J
B. 1.8×10^4 J
C. 2.0×10^4 J
D. 2.7×10^4 J

$W_{applied} = F_x \cdot 25 = 1000(\cos 37)(25)$

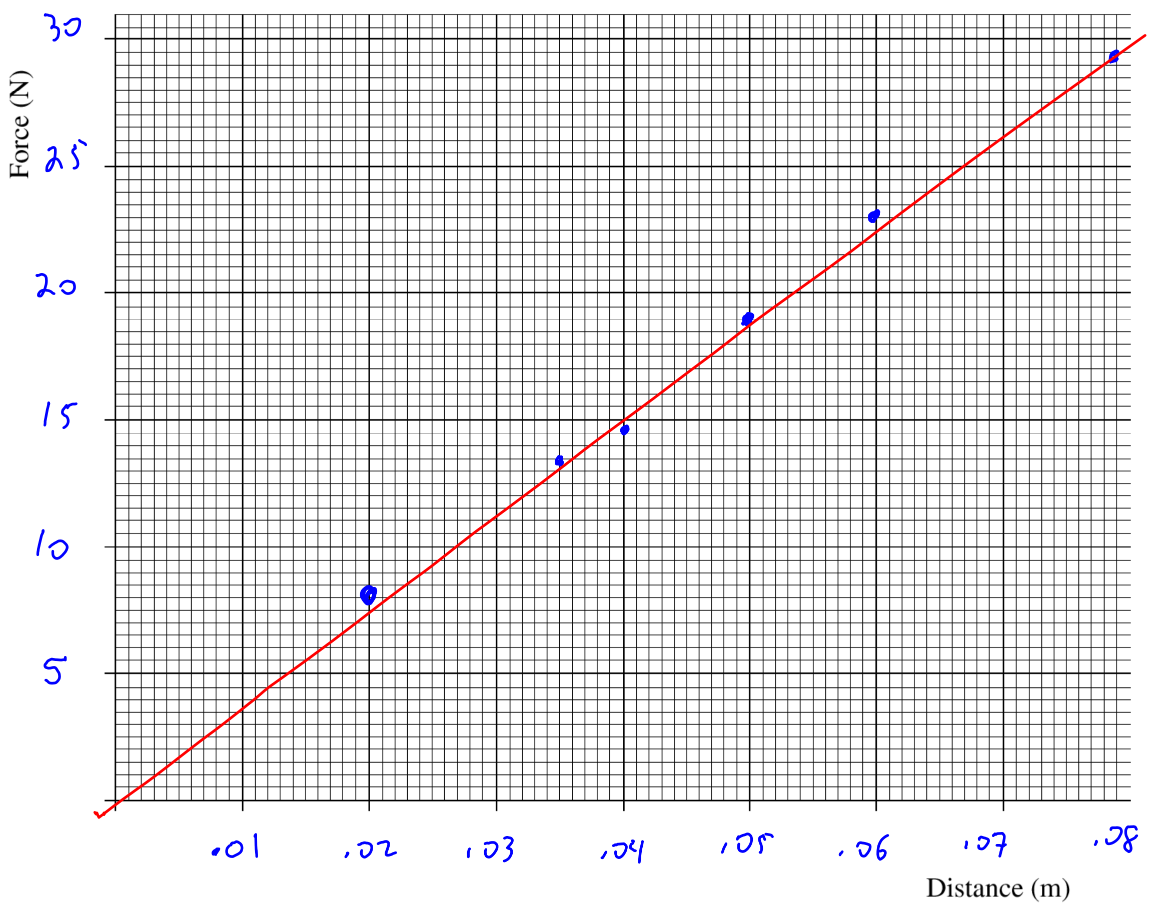
0306
40.
A small toy car is placed in a spring-loaded launcher.



The force needed to compress the spring is recorded as a function of distance.

a) Plot a graph of force vs. distance using the data table shown. **(2 marks)**

Force (N)	Distance (m)
7.5	0.020
13.2	0.035
14.8	0.040
19.1	0.050
23.0	0.060
29.5	0.080



b) Calculate the area under this graph from distance = 0.0 m to distance = 0.080 m. **(2 marks)**

$$A = \frac{bh}{2} = \frac{(.08)(29.5)}{2} = 1.2 \text{ J}$$

ANSWER:

area: 1.2 J

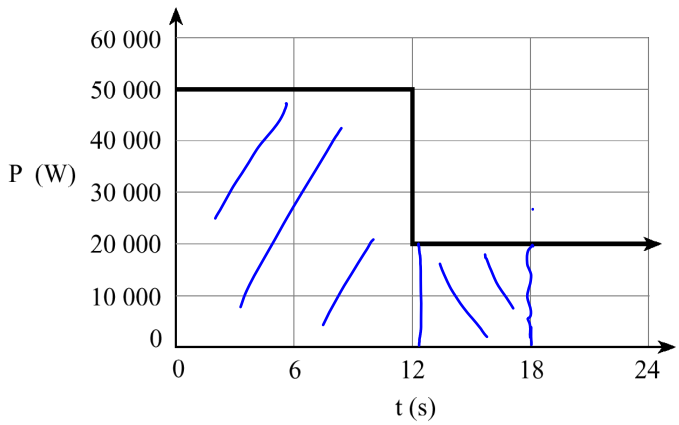
c) What does this area represent? **(1 mark)**

Work done to compress the spring or energy stored in the spring

Scholarship Questions! Really neat ones!
9506
41.

2. The graph shows power output versus time for a 2 100 kg electric car starting from rest. If 35% of the output power is lost due to friction, find the speed of the car at $t = 18$ s.

(12 marks)



$P = \frac{W}{t} \rightarrow W = P \cdot t$ = area under graph

$W = 12(50000) + 6(20000) = 7.2 \times 10^5$ J

However, we only get 65% efficiency.

$.65 \times 7.2 \times 10^5 = 468{,}000$ J ← this will become KE

$W = \Delta KE = KE_f - \cancel{KE_i}$

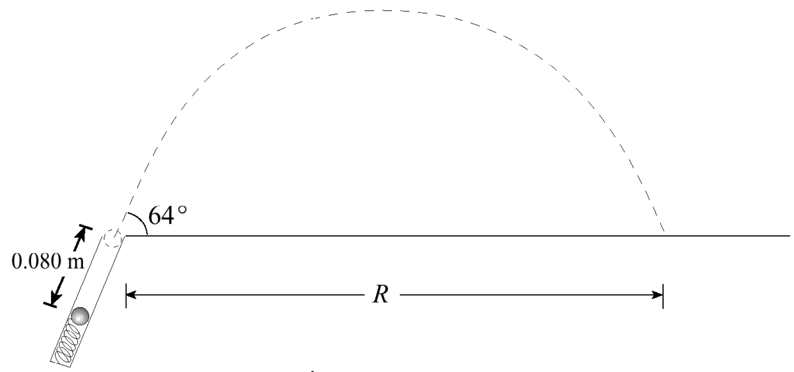
$468{,}000 = \frac{1}{2} m v_f^2 \rightarrow v_f = \sqrt{\frac{2(468{,}000)}{2100}}$

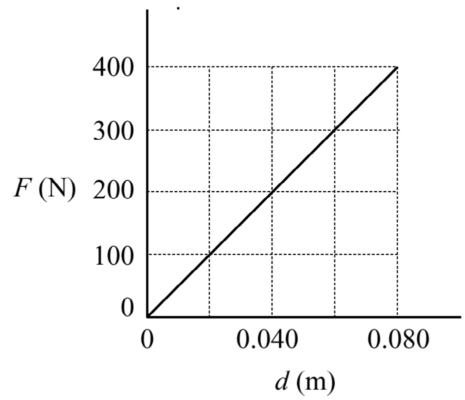
$v_f = 21.1$ m/s

9601

42.

1. A 0.060 kg steel ball is pushed 0.080 m down a launching tube against a spring. The force exerted by the spring increases from zero to 400 N as the ball is pushed down the tube, as shown in the graph below. (Assume no energy loss due to heat.)





$$W = \text{area} = \frac{(.08)(400)}{2}$$

$$W = 16\ J$$

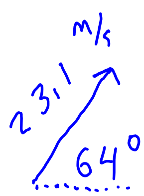
a) The ball is then released. What is the speed of the ball as it leaves the tube? **(6 marks)**

b) What is the range, *R*, of the ball? **(6 marks)**

a) $W = \Delta KE = KE_f - \cancel{KE_i}$

$16 = \frac{1}{2} m v_f^2 \longrightarrow v_f = \sqrt{\frac{2(16)}{.06}} = 23.1\ m/s$

b)



$V_y = 23.1 \sin 64$

$V_{y_i} = 20.76\ m/s$

$V_{y_f} = -20.76$

$t = \frac{v_{f_y} - v_{i_y}}{a} = 4.24$

$V_x = 23.1 \cos 64$

$V_x = 10.13\ m/s$

$d_x = v_x t = (10.13)(4.24)$

$d_x = 43\ m$

Answers:

1. b
2. d
3. a
4. b
5. b
6. b
7. c
8. a
9. c
10. c
11. b
12. c
13. v=20.7 m/s
14. b) 35 J c) the force applied to the lawnmower
15. a) .90 J b) 7.7 m/s c) 20%
16. a) 1380 J b) 580 J c) 42%
17. c
18. b
19. a) 7.6 W b) 38 W
20. 18 m/s
21. b) 2.85×10^4 J
22. a) 1.16×10^4 J b) 190 N
23. a) 50 kg b) ½ of the mass
24. a
25. b
26. c
27. c
28. c
29. b
30. b
31. b
32. c
33. c
34. a) 9.1 m b) see my solution key
35. c
36. b
37. b
38. a
39. c
40. b) 1.2 J c) the work done on the spring or the potential energy stored in the spring
41. v=21 m/s
42. a) 23.1 m/s b) 42.9 m