Name: Key

Work, Energy, and Momentum Provincial Exam Questions

1. Is power a scalar or vector quantity, and which are the correct units for measuring it?

$P = \frac{W}{t}$

	TYPE OF QUANTITY	UNITS
A.	Scalar ✓	J/m
✓ (B.)	Scalar ✓	J/s ✓
C.	Vector	J/m
D.	Vector	J/s

2. A climber's gravitational potential energy increases from 14 000 J to 21 000 J while climbing a cliff. She expends 18 000 J of energy during this activity. What is the efficiency of this process?
   A. 3%
   ✓ (B.) 39%
   C. 61%
   D. 97%

$eff = \frac{W_{out}}{W_{in}} = \frac{7000\,J}{18000\,J} \times 100\% =$

3. A 40 000 kg rail car travelling at 2.5m/s collides with and locks to a stationary 30 000 kg car. Determine the speed of the locked cars and state whether the collision is elastic or inelastic.

$P_1 + P_2 = P_{12}$ ($P_2 = 0$)

$40000(2.5) = 70000(V)$

$V = 1.4\,m/s$

E_k before $= 1.25 \times 10^5$
E_k after $= 7.1 \times 10^4$
not equal so inelastic

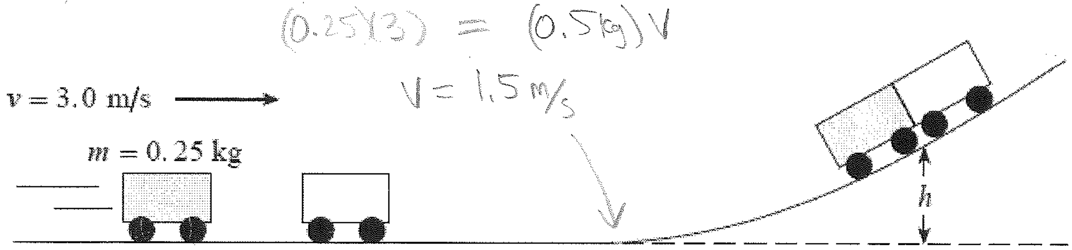
	SPEED OF LOCKED CARS	TYPE OF COLLISION
~~A.~~	1.4 m/s	Elastic
✓ (B.)	1.4 m/s	Inelastic ✓
~~C.~~	1.9 m/s	Elastic
D.	1.9 m/s	Inelastic ✓

4. A 0.25kg cart travelling at 3.0 m/s collides with and sticks to an identical stationary cart on a level track (ignore friction).

$P_i = P_f$

$(0.25)(3) = (0.5\,kg)V$

$V = 1.5\,m/s$



To what height *h* do the combined carts travel up the hill?

$E_{k\,bott} = E_{p\,up\,hill}$

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

$h = \frac{v^2}{2g} = \frac{(1.5\,m/s)^2}{2(9.8\,m/s^2)} = 0.11\,m$ ✓

5. A cyclist must do 1 000 J of work to speed up from 0 m/s to 5.0 m/s. the same cyclist must do 3 000 J of work to speed up from 5.0 m/s to 10.0 m/s (in both instances, friction has been ignored). Using principles of physics, explain why more work must be done to speed up from 5.0 m/s to 10.0 m/s than from 0 m/s to 5.0 m/s (remember, friction plays no role in this problem).

$W = \Delta E = \frac{1}{2}m(v_f^2 - v_o^2)$

1st $= \frac{1}{2}m(25-0)$

2nd $= \frac{1}{2}m(100-25)$

v changes by 5 m/s, but v is squared, so E changes more

6. A cyclist increases his kinetic energy from 1 100 J to 5 200 J in 12 s. his power output during this time is ____?

$P = \frac{\Delta E}{t} = \frac{5200-1100}{12\ s} = 342$ Watts $= 3.4 \times 10^2$ W

7. Which of the following best represents the momentum of a small car travelling at a city speed limit?

~1000 kg

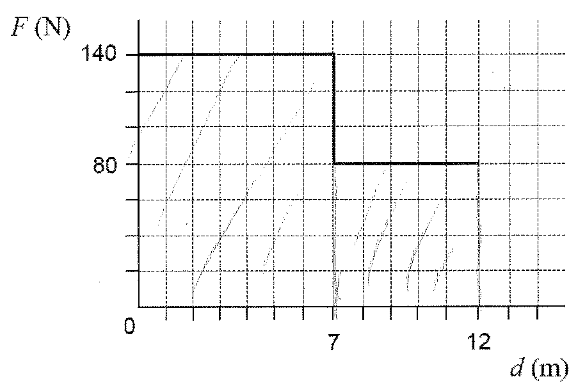
A. 1 000 kg·m/s
B. 10 000 kg·m/s
C. 100 000 kg·m/s
D. 1 000 000 kg·m/s

$p = mv$
$= 1000(50\ km/h \times \frac{1\ h}{3600\ s} \times \frac{1000\ m}{1\ km})$
$= 14000$ kg m/s ← closest to 10 000

8. A 0.080 kg tennis ball travelling east at 15 m/s is struck by a tennis racquet, giving it a velocity if 25 m/s west. What are the magnitude and direction of the impulse given to the ball?

imp $= \Delta p = m(25\ m/s\ W - 15\ m/s\ E) = (0.08)(25W + 15W) = 3.2$ N·s [W]

9. 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) How much work did the farmer do moving the cart 12 m? Area $= 140\ N \cdot 7\ m + 80\ N \cdot 5\ m = 1380$ J $= 1.4 \times 10^3$ J
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? $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(240\ kg)(2.2\ m/s)^2 = 580.8$ J $= 5.8 \times 10^2$ J
c) What was the efficiency of this process?

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

10. Define inelastic collision.

E_k is not conserved

11. Which of the following correctly describes momentum and impulse?

	MOMENTUM	IMPULSE
A.	vector	vector
B.	vector	scalar
C.	scalar	vector
D.	scalar	scalar

✓ (A.)

12. A stationary object explodes into two fragments. A 4.0 kg fragment moves westwards at 3.0 m/s. what are the speed and kinetic energy of the remaining 2.0 kg fragment?

(#12) before & after $0 = P_1 + P_2 = 4 \times 3 + 2 \times v$, $v = 6\frac{m}{s}$ [E] ✓

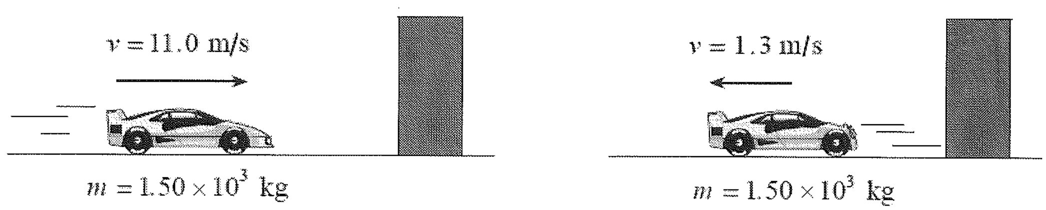
$E_k = \frac{1}{2}mv^2 = \frac{1}{2}(2kg)(6\frac{m}{s})^2 = 36J$ ✓

13. A 1 000 kg vehicle travelling westward at 15 m/s is subjected to a 1.0×10^4 N·s impulse northward. What is the magnitude of the final momentum of the vehicle?

$imp = \Delta p = P_f - P_i$ $P_f = \Delta p + P_i$ $P_f^2 = \Delta p^2 + P_i^2 = (1 \times 10^4)^2 + (1000 \cdot 15)^2$

$P_f = 1.8 \times 10^4 kg\frac{m}{s}$ ✓

14. A 1.50×10^3 kg car travelling at 11.0 m/s collides with a wall as shown.



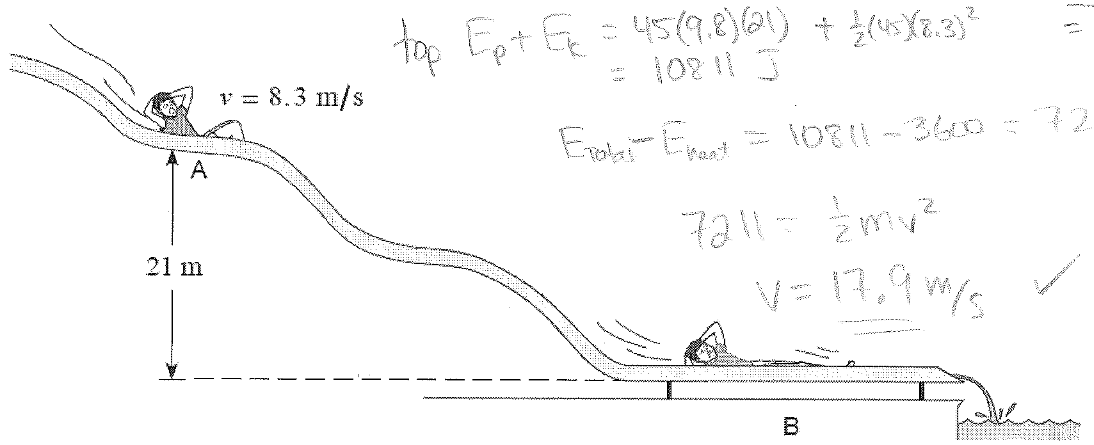
The car rebounded off the wall with a speed of 1.3 m/s. if the collision lasts for 1.7 s. what force does the wall apply to the car during the collision?

$imp = F\Delta t = \Delta p = P_f - P_i$

$F(1.7s) = (1.5 \times 10^3)(-1.3) - (1.5 \times 10^3)(11\frac{m}{s})$

$F = -1.1 \times 10^4 N$ ✓ $= 1.1 \times 10^4 N$ [left]

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



top $E_p + E_k = 45(9.8)(21) + \frac{1}{2}(45)(8.3)^2 = 10811 J$

$E_{Total} - E_{heat} = 10811 - 3600 = 7211 J$ bottom

$7211 = \frac{1}{2}mv^2$

$V = 17.9 m/s$ ✓ $= 18\frac{m}{s}$

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?

16. What is the minimum work done when a 65 kg student climbs an 8.0 m high stairway in 12 s?

$W = \Delta E = mgh = (65)(9.8)(8) = 5.1\times10^3$ J ✓

red herring!

17. Which of the following is equal to impulse?

A. Energy
B. Momentum
C. Change in energy
D. Change in momentum ✓

18. A 1 500 kg car travelling at 25 m/s collides with a 2 500 kg van stopped at a traffic light. As a result of the collision, the two vehicles become entangled. With what initial speed will the entangled mass move off, and is the collision elastic or inelastic?

$\frac{1}{2}(1500)25^2 \overset{?}{=} \frac{1}{2}(4000)9.4^2$ ≠ so inelastic

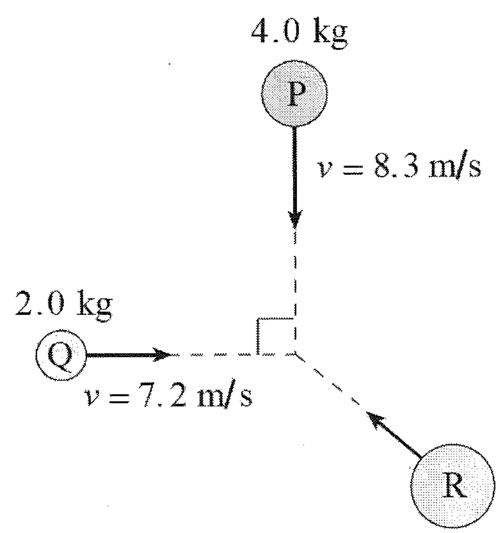
before after

$\vec{P}_c + \vec{P}_v = \vec{P}_{cv}$

$(1500)(25) = 4000(v)$

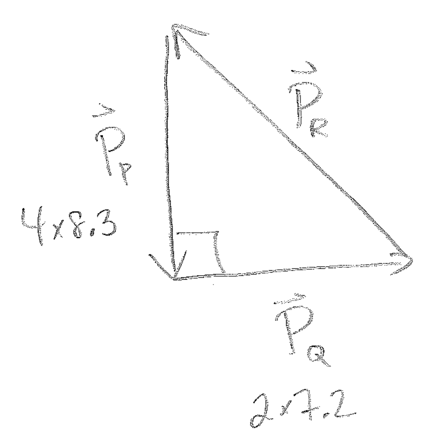
$v = 9.4$ m/s ✓

19. Three objects travel as shown.



What is the magnitude of the momentum of object R so that the combined masses remain stationary after they collide?

equilibrium △

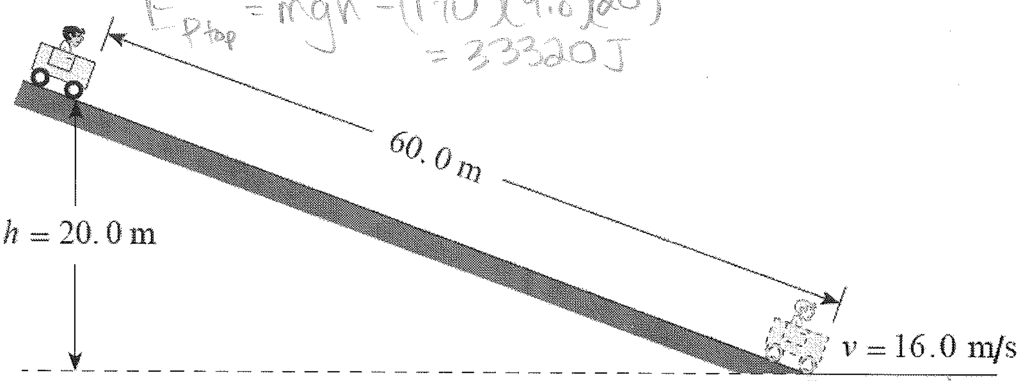


pythagorus

$P_R = 36$ kg m/s ✓

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

$E_{p\,top} = mgh = (170)(9.8)(20) = 33320\text{ J}$



$E_{k\,bott} = \frac{1}{2}mv^2 = \frac{1}{2}(170)(16)^2 = 21760\text{ J}$

a) How much energy is transformed to heat? $E_h = 33320 - 21760 = 11560 = 1.16\times10^4\text{ J}$ ✓

b) What is the average force of friction acting on the cart?

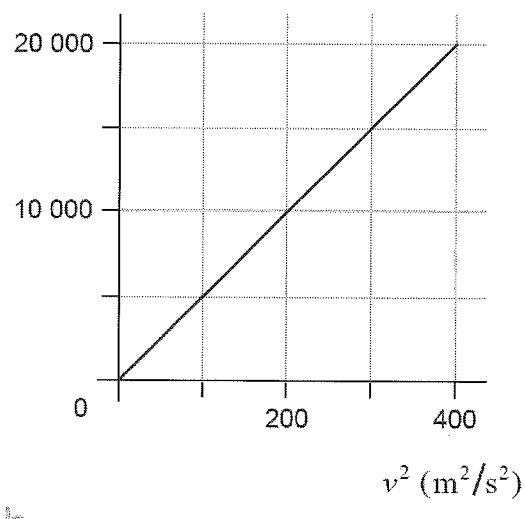
$E_h = F_f d \qquad F_f = \frac{E_h}{d} = \frac{11560}{60} = 1.93\times10^2\text{ N}$ ✓

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

a) What is the slope of this graph?

b) What does the slope represent?

c) Sketch the graph of kinetic energy E_k versus velocity v for this motorbike. There is no need to plot any data points.

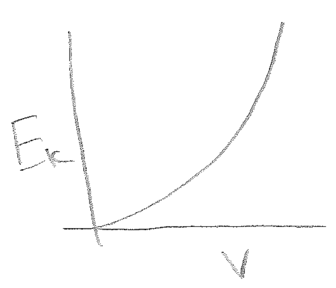


a) slope $= \frac{\text{rise}}{\text{run}} = \frac{20\,000}{400} = 50\ \frac{\text{J}}{\text{m}^2/\text{s}^2}$

$= 50\ \frac{\text{kg}(\text{m/s})^2}{\text{m}^2/\text{s}^2} = 50\text{ kg}$

b) $E_k = \frac{1}{2}mv^2$, slope $= \frac{1}{2}m$

c)

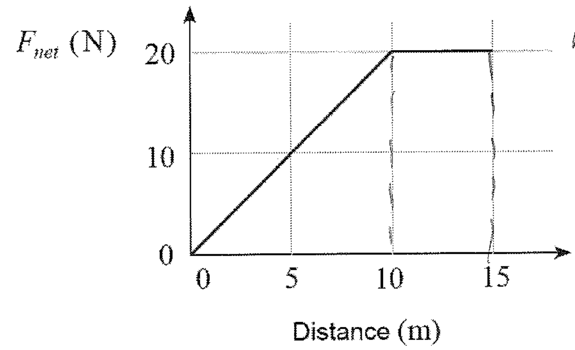


v	E_k
1	1
2	4
3	9
4	16

$V_0 = 0$

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

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



Area = work $= \frac{1}{2} 20 \times 10 + 20 \cdot 5 = 200\text{J}$

$W = \Delta E = \frac{1}{2} m (v_f^2 - v_0^2)$

$200\text{J} = \frac{1}{2}(8) v_f^2$

$v_f = 7.1 \text{ m/s}$ ✓

$\text{eff} = \frac{P_{out}}{P_{in}} \times 100\%$

23. 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?

$P_{out} = \frac{W}{t} = \frac{Fd}{t} = \frac{mgd}{t} = \frac{100(9.8)(36)}{45} = 784$ $\quad \text{eff} = \frac{784}{1500} \times 100\% = 52\%$ ✓

24. Two cars collide head-on and come to a complete stop immediately after the collision. Which of the following is correct?

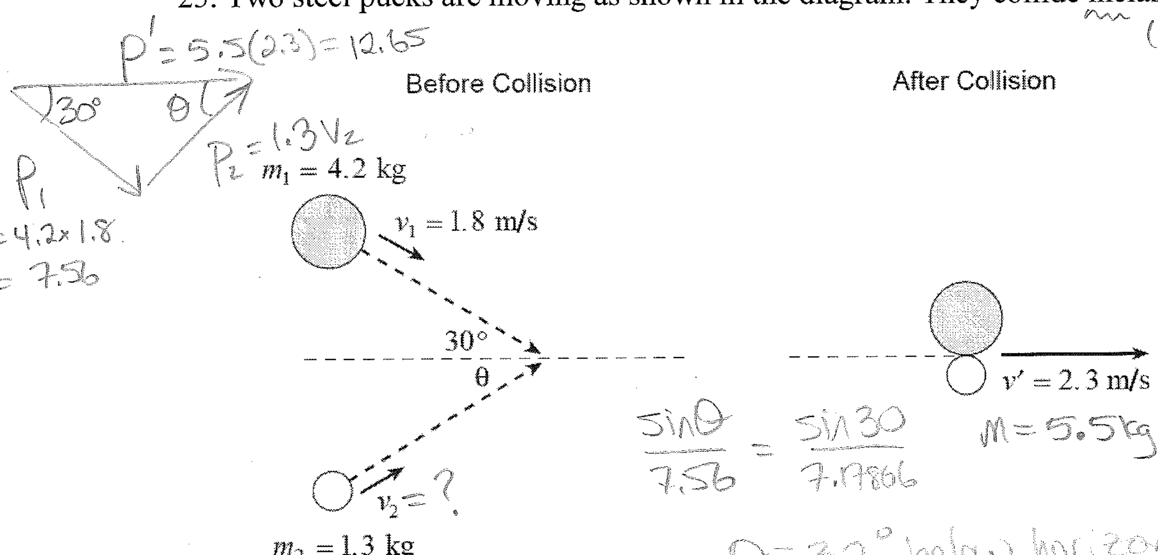
	Total Momentum	Total Energy
(A)	Is Conserved ✓	Is Conserved ✓
B	Is Conserved ✓	Is **NOT** Conserved
C	Is **NOT** Conserved	Is Conserved ✓
D	Is **NOT** Conserved	Is **NOT** Conserved

25. Two steel pucks are moving as shown in the diagram. They collide inelastically. (so not 90°)

$p' = 5.5(2.3) = 12.65$

$p_2 = 1.3 v_2$

$p_1 = 4.2 \times 1.8 = 7.56$



$M = 5.5\text{kg}$

$\frac{\sin\theta}{7.56} = \frac{\sin 30}{7.17866}$

$\theta = 32°$ below horizontal ✓

Determine the speed and direction (angle Θ) of the 1.3 kg puck before the collision.

$p_2^2 = p_1^2 + p'^2 - 2 p_1 p' \cos 30°$

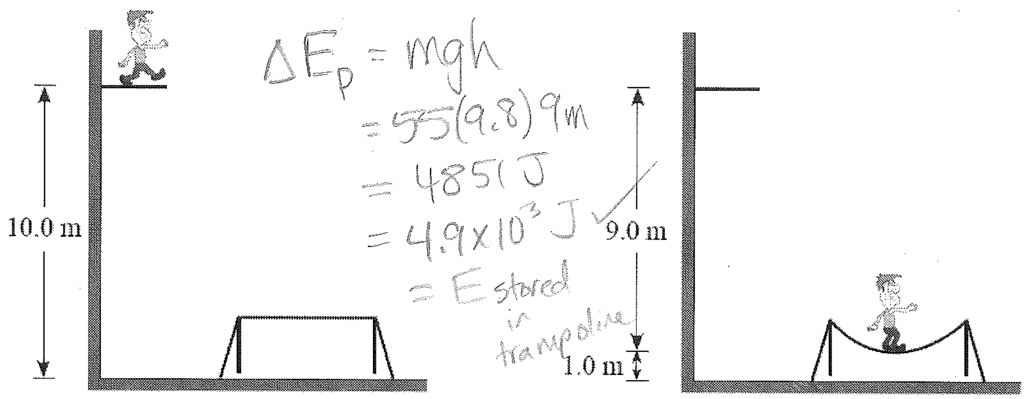
$p_2 = 7.17866 = m_2 v_2$

$v_2 = \frac{7.17866}{1.3\text{kg}} = 5.5 \text{ m/s}$ ✓

$t = \frac{d}{v}$ $mgh \times \frac{v}{d}$

26. A 950 kg elevator ascends a vertical height of 410 m with an average speed of 9.1 m/s. What average power must the lifting motor supply? $P = \frac{E}{t} = \frac{mgh}{h/v} = mgv = 8.5\times10^4\ W$ ✓

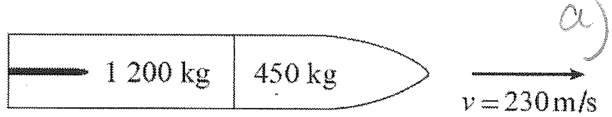
27. A 55.0 kg athlete steps off a 10.0 m high platform and drops onto a trampoline. As the trampoline stretches, it brings him to a stop 1.00 m above the ground.



$\Delta E_p = mgh$
$= 55(9.8)9\text{m}$
$= 4851\ J$
$= 4.9\times10^3\ J$ ✓
= E stored in trampoline

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

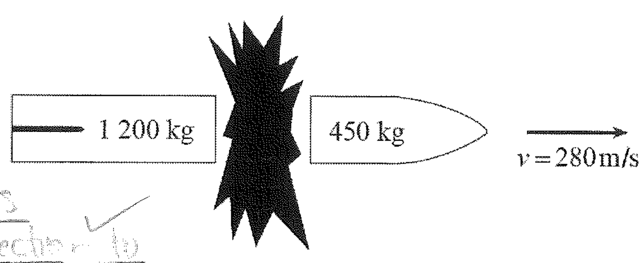
28. A space vehicle made up of two parts is travelling at 230 m/s as shown.



a) $p = mv$
$= 1650(230)$
$= 3.8\times10^5\ kg\frac{m}{s}$ ✓

An explosion causes the 450 kg part to separate and travel with a final velocity of 280 m/s as shown.

b) imp $= \Delta p = m\Delta v$
$= m(v_f - v_o)$
$= 450(280-230)$
$= 2.25\times10^4\ N\cdot s$ ✓
opposite direction to other part.

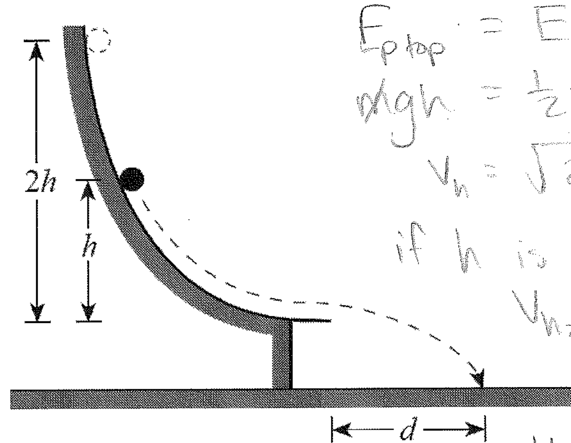


a) What was the momentum of the space vehicle before the explosion?
b) What was the magnitude of the impulse on the 1 200 kg part during the separation?
c) Using principles of physics, explain what changes occur, if any, to the
   i. momentum of the system as a result of the explosion. – momentum always conserved ✓
   ii. kinetic energy of the system as a result of the explosion.

explosion added kinetic energy to system (converted from chemical) ✓

29. 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.

V_h = constant



$E_{p\,top} = E_{k\,bottom}$

$mgh = \frac{1}{2}mv_h^2$

$V_h = \sqrt{2gh}$

if h is doubled:

$V_{h2} = \sqrt{2g(2h)} = \sqrt{2}\sqrt{2gh}$

$V_{h2} = \sqrt{2}\,V_h$

then: $V_h = \frac{d_h}{t}$

The same object is ~~not~~ released from twice the height, $2h$. How far away will it land?

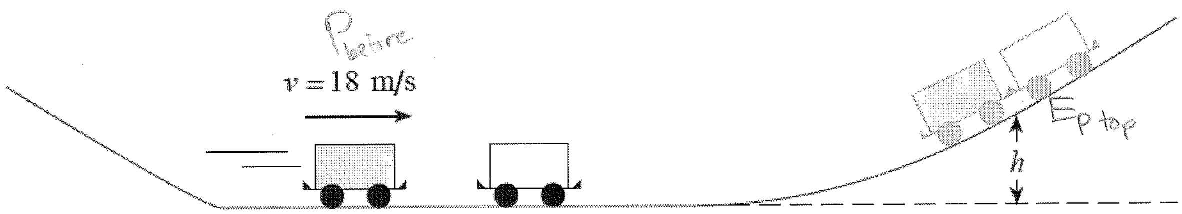
A. d
B. $\sqrt{2}\,d$ ✓
C. $2d$
D. $4d$

$d_h = V_h t$

$d_{h2} = \sqrt{2}(V_h t)$

$d_{h2} = \sqrt{2}\,d_h$

30. A 360 kg roller coaster car travelling at 18 m/s collides inelastically with a stationary 240 kg car on a section of horizontal track as shown in the diagram below.



To what maximum height, h, do the combined cars travel before rolling back down the hill (assume no friction)? So no loss of E to heat

$P_{before} = P_{after}$

$m_1v_1 + m_2v_2 = (m_1+m_2)V$

$(360)(18) = (360+240)V$

$V = 10.8\ m/s$

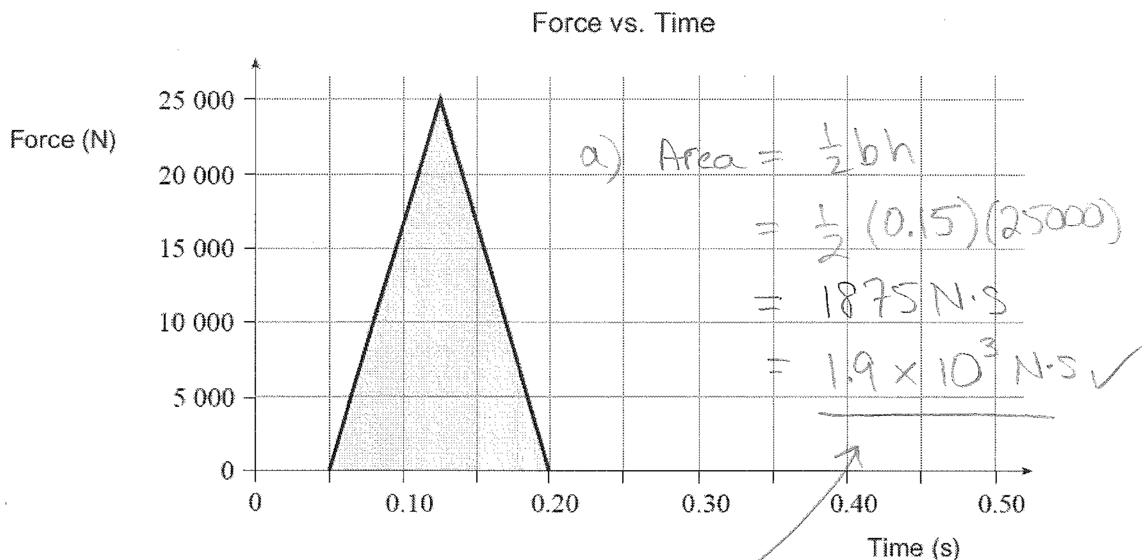
$E_{k\,bott} = E_{p\,top}$

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

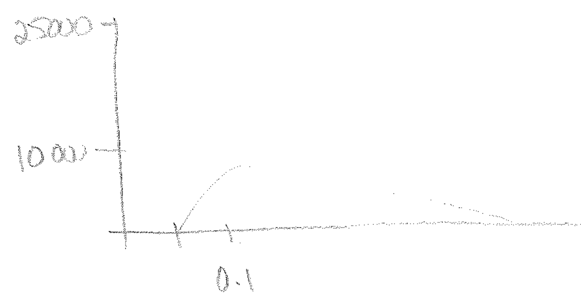
$h = \frac{v^2}{2g} = \frac{(10.8)^2}{2(9.8)}$

$= 5.95 = 6.0\ m$ ✓

31. During a motor vehicle accident, an unbelted passenger experienced a force which varied with time as shown on the graph.



a) Calculate the area of the shaded region in the graph.
b) What does this area represent? impulse ($F \cdot \Delta t$)
c) If the passenger was wearing a seatbelt properly, the maximum force would have been one third the force experienced without the seatbelt. Sketch on the graph below how the force on the belted passenger might have varied with time.



area = impulse would still equal 1.9×10^3 N·s but spread over a longer time as held against seatbelt. So not as much force.

$$\Delta p = p_f - p_i$$