Physics 12 Name:

The Ultimate Vector Momentum Assignment

Key Formulae:

$$\vec{p} = m\vec{v} \quad \text{and} \quad \Delta\vec{p} = \vec{F}\Delta t$$

REMEMBER, MOMENTUM IS A VECTOR!!!! YOU WILL BE DRAWING TIP-TO-TAIL VECTOR DIAGRAMS FOR MOST QUESTIONS, UNLESS NO ANGLES ARE MENTIONED!

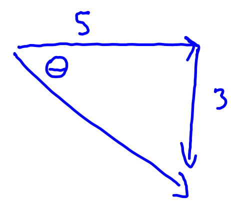
9401

1. N W E S

A 2.0 kg puck travelling due east at 2.5 m/s collides with a 1.0 kg puck travelling due south at 3.0m/s. They stick together on impact. What is the resultant direction of the combined pucks?

A. 31° S of E
B. 40° S of E
C. 50° S of E
D. 59° S of E

$\overrightarrow{(2.0)(2.5)}$ + $(1)(3)\downarrow$ =



$\theta = \tan^{-1}(3/5)$

$\theta = 31°$

2.

A 5.20 kg block sliding at 9.40 m/s across a horizontal frictionless surface collides head on with a stationary 8.60 kg block. The 5.20 kg block rebounds at 1.80 m/s. How much kinetic energy is lost during this collision? **(7 marks)**

$$\Sigma \vec{p}_i = \Sigma \vec{p}_f$$

$$\overrightarrow{(5.2)(9.4)} + 0 = \overleftarrow{(5.2)(1.8)} + \overrightarrow{(8.6)(v_{2_f})}$$

$$(5.2)(9.4) = -5.2(1.8) + 8.6\, v_{2_f}$$

$$v_{2_f} = \frac{(5.2)(9.4) + 5.2(1.8)}{8.6} = 6.77 \text{ m/s}$$

Total KE before collision $= \frac{1}{2} m_1 v_1^2 = \frac{1}{2}(5.2)(9.4)^2 = 229.7$

Total KE after $= \frac{1}{2} m_1 v_{1_f}^2 + \frac{1}{2} m_2 v_{2_f}^2 = 205.5$

Energy lost $= 229.7 - 205.5 = 24$ J

3.

Two gliders having equal masses, each travelling along a level frictionless track at the same speed, approach each other head on. They stick together on impact and remain stationary at the point of impact. Does this situation mean that momentum has been lost during this particular collision? State your answer with supporting arguments which use principles of physics. **(4 marks)**

See my answer key at the end of document

9406

4.

A puck sliding on a frictionless table undergoes a change in momentum due to a constant force. Which of the following expressions could be used to determine the change in momentum?

impulse

A. $F \times \Delta d$

B. $F \times \Delta t$

C. $F \times \Delta v$

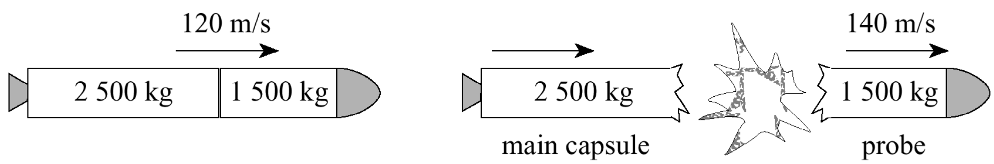
D. $F \times (\Delta v / \Delta t)$

$F\Delta t$ = impulse or change in momentum

5.

A 4 000 kg space vehicle consists of a 2 500 kg main capsule and a 1 500 kg probe. The space vehicle is travelling at 120 m/s when an explosion occurs between the capsule and the probe. As a result, the probe moves forward at 140 m/s, as shown in the diagram below.

Before After



a) (i) What is the speed of the main capsule after the explosion? **(3 marks)**

(ii) What is the magnitude of the impulse given to the probe? **(2 marks)**

a) i) $\sum \vec{p}_i = \sum \vec{p}_f$

$(m_1+m_2)v_i = m_1 v_{1f} + m_2 v_{2f}$

$(4000)(120) = 2500\, v_{1f} + 1500(140)$ $v_{1f} = 108$ m/s

ii) $\Delta \vec{p} = \vec{p}_f - \vec{p}_i = (1500)(140) - 1500(120) = 3.0\times10^4$ N·s

b) Define *impulse* and briefly explain why the impulse on the probe is equal in magnitude to the impulse on the main capsule. **(4 marks)**

see answer key at end of document

9501

6.

Impulse is measured in which units?

A. J
B. N
C. $N \cdot m$
D. $N \cdot s$

$\Delta \vec{p} = \vec{F} \Delta t$

N s

9508

7.

Two carts collide while travelling on a smooth surface. It is found that the sum of the kinetic energies of the carts after the collision is the same as before the collision. This collision **must** be

A. elastic.
B. inelastic.
C. between carts of identical mass.
D. between carts that stick together.

8.

In order to stop two sliding objects, the greater impulse **must** be given to the one having the greater

A. mass.
B. speed.
C. velocity.
D. momentum.

9601

9.

Which expression is equal to the net force on an object?

A. $\dfrac{\Delta p}{\Delta t}$

B. $\dfrac{W}{\Delta t}$

C. $m\Delta v$

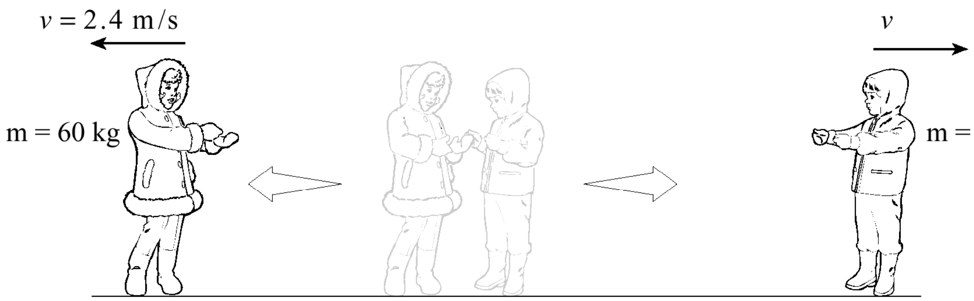
D. ΔE

$\Delta \vec{p} = \vec{F} \Delta t \rightarrow \vec{F} = \dfrac{\Delta \vec{p}}{\Delta t}$

9606

10.

A 60 kg girl and her 45 kg brother are at rest at the centre of a frozen pond. He pushes her so that she slides away at 2.4 m/s. How much total work is done? (Ignore friction.)



$W = \Delta KE$

we need v_{girl} and v_{boy}

A. 58 J
B. 170 J
C. 350 J
D. 400 J

$\Sigma \vec{p}_i = \Sigma \vec{p}_f$

$0 = m_g \vec{v}_g + m_b v_b$

$v_{boy} = \frac{-m_g \vec{v}_g}{m_b} = -3.2$ m/s

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

$= \left(\frac{1}{2} m_g v_g^2 + \frac{1}{2} m_b v_b^2\right)$

9608

11.

Impulse is defined as

A. total energy.
B. total momentum.
C. a change in energy.
D. a change in momentum.

9701

12.

Which of the following describes kinetic energy and momentum before and after a perfectly elastic collision?

Key phrase

	KINETIC ENERGY	MOMENTUM
A.	Not Conserved ✗	Not Conserved ✗
B.	Not Conserved ✗	Conserved ✓
C.	Conserved ✓	Not Conserved ✗
D.	Conserved ✓	Conserved ✓

momentum: always conserved

Total Energy: always conserved

Kinetic Energy: only conserved in a perfectly elastic collision

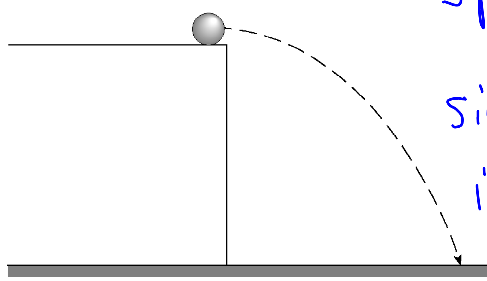
13.

A 0.30 kg ball rolls off a horizontal surface as shown in the diagram. What is the magnitude of the impulse given to the ball by gravity during the 0.90 s it takes the ball to fall to the ground?

$v_{y_f} = v_{y_i} + at$

$v_{y_f} = 0 + (-9.8)(.9)$

$v_{y_f} = -8.82$



$\Delta\vec{p} = \vec{p}_f - \vec{p}_i = \vec{p}_f + (-\vec{p}_i)$

since v_x is constant, there is no horizontal Δp

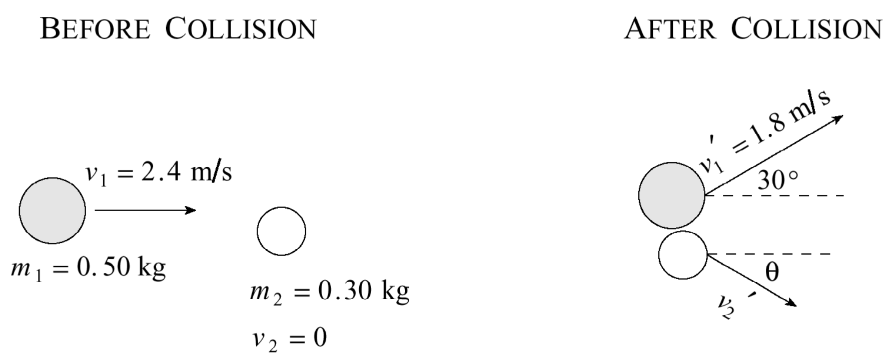
A. 1.5 N·s
B. 2.6 N·s
C. 3.0 N·s
D. 4.1 N·s

$\Delta\vec{p}_y = mv_{y_f} - mv_{y_i}$

$= (.3)(8.8) - 0$

14.

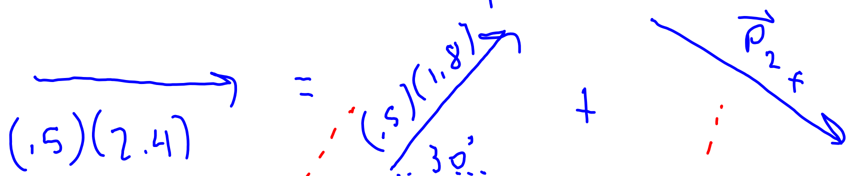
Two steel pucks collide as shown in the diagram below.

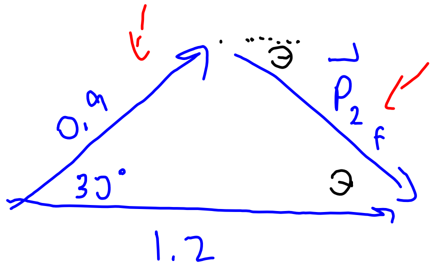


Determine the speed and direction (angle θ) of the 0.30 kg puck after the collision. **(7 marks)**

$$\sum \vec{p}_i = \sum \vec{p}_f$$

$$\vec{p}_{1_i} = \vec{p}_{1_f} + \vec{p}_{2_f}$$





$$p_{2_f}^2 = (.9)^2 + (1.2)^2 - 2(.9)(1.2)\cos 30°$$

$$p_{2_f} = .615$$

$$\frac{\sin\theta}{.9} = \frac{\sin 30}{.616}$$

$$m_2 \vec{v}_{2_f} = .616 \qquad v_{2_f} = \frac{.616}{m_2} = 2.05 \text{ m/s}$$

$$\vec{v}_f = 2.05 \text{ m/s @ } 47° \text{ S of E}$$

9706

15.

Which equation is a form of Newton's second law?

A. $\vec{F}_{net} = \dfrac{\Delta \vec{p}}{\Delta t}$

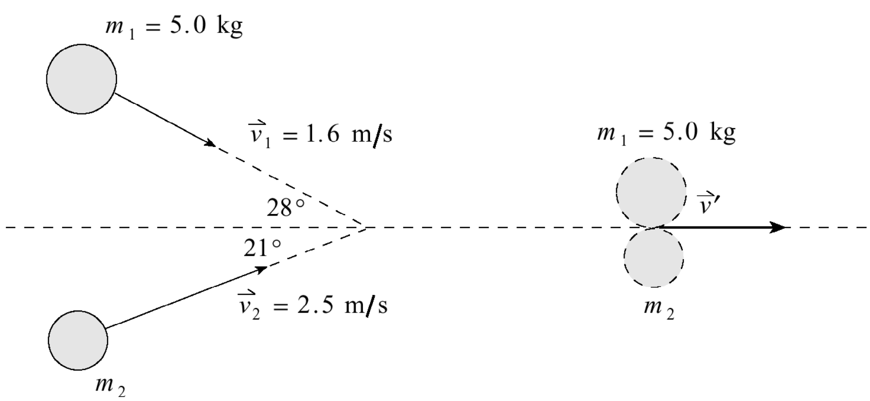
B. $W = \Delta E$

C. $E_k + E_p = E_k' + E_p'$

D. $\mathcal{E} = -N\dfrac{\Delta \Phi}{\Delta t}$

16.

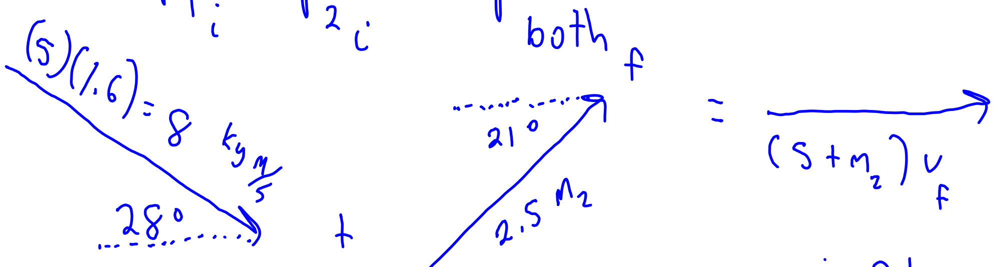
A $5.0\ \text{kg}$ object travelling at $1.6\ \text{m/s}$ collides with an object of unknown mass m_2 travelling at $2.5\ \text{m/s}$. The two objects stick together and move towards the right as shown in the diagram.

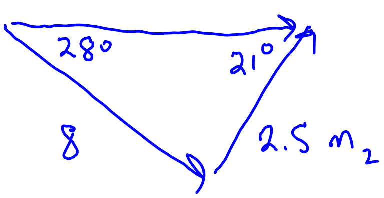


Find the mass of object m_2. **(7 marks)**

$$\sum \vec{p}_i = \sum \vec{p}_f$$

$$\vec{p}_{1_i} + \vec{p}_{2_i} = \vec{p}_{both_f}$$





use sine law.

$$\frac{\sin 21}{8} = \frac{\sin 28}{2.5 m_2}$$

$$m_2 = \frac{8 \sin 28}{2.5 \sin 21} = 4.2\ \text{kg}$$

9708
17.

Which of the following is a correct unit for impulse?

A. N
B. N · m
C. N/s
D. N · s

18. negative

A 0.15 kg ball travelling at 25 m/s strikes a wall and bounces back in the opposite direction at 15 m/s. The ball is in contact with the wall for 0.030 seconds. What average force does the wall exert on the ball?

positive

A. 25 N
B. 50 N
C. 1.0×10^2 N
D. 2.0×10^2 N

$F\Delta t = \Delta p$

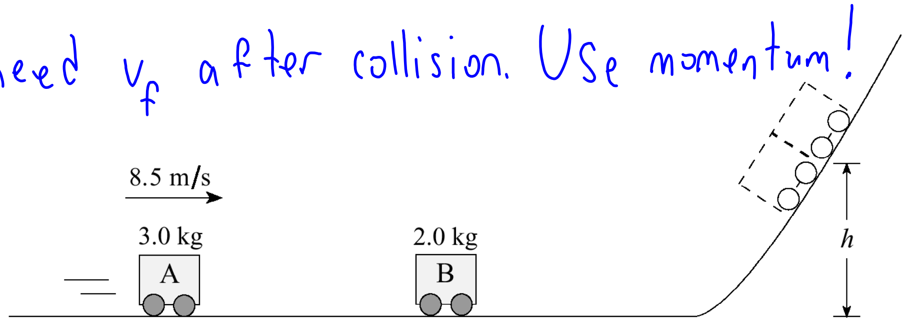
$F\Delta t = m\vec{v}_f - m\vec{v}_i$

$F = \frac{(.15)(15) - (.15)(-25)}{.03} = 200\ N$

19.

A 3.0 kg car A travelling 8.5 m/s on a frictionless track collides and sticks on to a stationary 2.0 kg car B.

We need v_f after collision. Use momentum!



a) The combined cars will reach what height h? **(5 marks)**

$\Sigma \vec{p}_i = \Sigma \vec{p}_f$

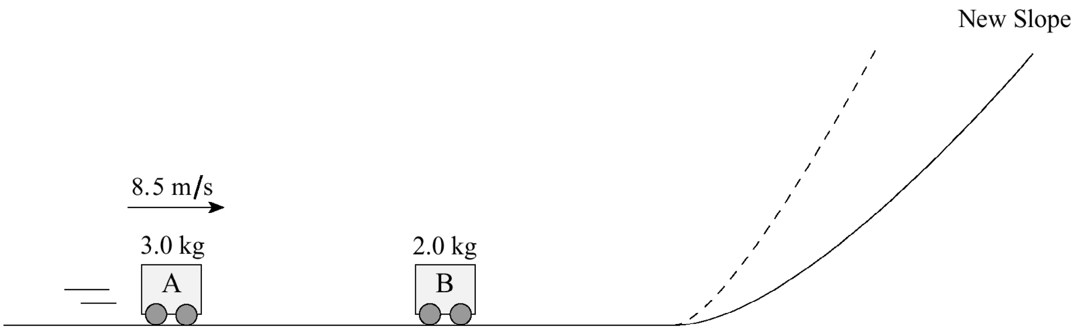
$m_1\vec{v}_{1i} + \cancel{m_2\vec{v}_{2i}} = m_{both}\vec{v}_f \rightarrow \vec{v}_f = \frac{m_1 v_{1i}}{m_{both}} = 5.1\ m/s$

Now, use energy!

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

$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh_f \longrightarrow h_f = \frac{v^2}{2g} = \frac{5.1^2}{2(9.8)} = 1.3\ m$

b) The steepness of the slope is decreased as shown below.



With this decreased slope, the combined cars will reach (check one response) **(1 mark)**

- ❒ a lesser height.
- ❒ the same height.
- ❒ a greater height.

c) Using principles of physics, explain your answer to b). **(3 marks)**

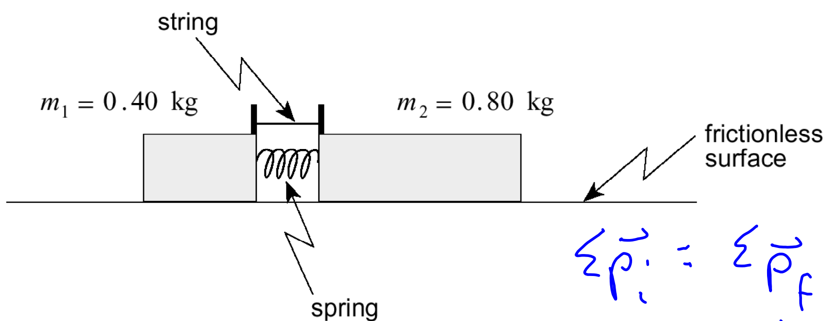
energy is a scalar, so steepness is irrelevant.

$\therefore KE_i = PE_f$, and h_f will be the same.

9801

20.

Two blocks are initially held together on a frictionless surface as shown in the diagram below.

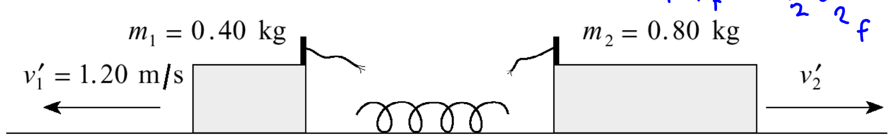


$$\sum \vec{p}_i = \sum \vec{p}_f$$

$$0 = m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f}$$

When the string is cut, the blocks fly apart as shown.

$$-m_1 \vec{v}_{1f} = m_2 \vec{v}_{2f} \rightarrow v_{2f} = \frac{-m_1 v_{1f}}{m_2}$$



$$v_{2f} = -0.6 \text{ m/s}$$

What work was done on the blocks by the spring?

A. 0 J
B. 0.29 J
C. 0.43 J
D. 0.58 J

$$W = \Delta KE = KE_f - \cancel{KE_i}^{=0}$$

$$= \left(\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2\right) = 0.43 \text{ J}$$

21.

A ball is thrown at 15 m/s towards various barriers. In which case does the ball experience the greatest impulse?

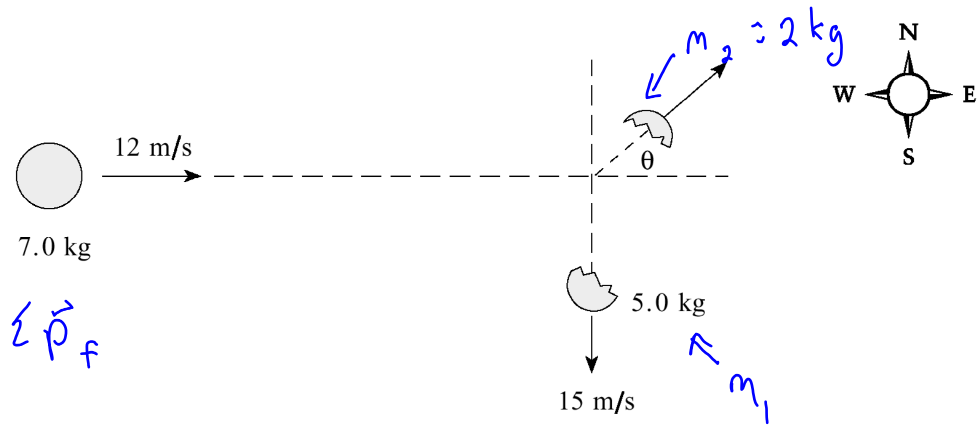
We want greatest $\Delta \vec{p}$

A. The ball hits a wall and rebounds at 2.0 m/s.
B. The ball hits a wall and rebounds at 7.0 m/s.
C. The ball hits a wall, sticks to it and stops moving.
D. The ball breaks a window and continues moving at 10 m/s in the same direction.

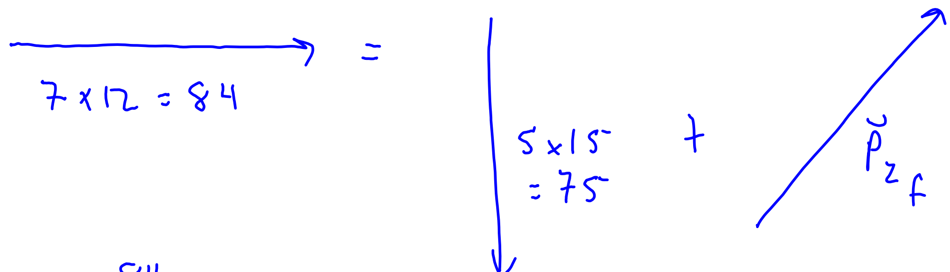
22.

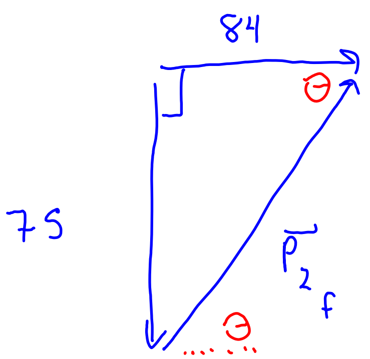
A 7.0 kg object moving at 12 m/s to the east explodes into two unequal fragments. The larger 5.0 kg fragment moves at 15 m/s south.

$\sum \vec{p}_i = \sum \vec{p}_f$



What is the velocity (speed and direction) of the smaller 2.0 kg fragment? **(7 marks)**





$p_{2f}^2 = 84^2 + 75^2$

$p_{2f} = 112.61 \qquad v_{2f} = \frac{112.61}{2} = 56.3$ m/s

$\theta = \tan^{-1}\left(\frac{75}{84}\right) = 42°$

$\boxed{\vec{v}_f = 56.3 \text{ m/s @ } 42° \text{ N of E} \quad \text{or } 48° \text{ E of N}}$

9806

23.

Which of the following are equivalent units for change in momentum?

A. $kg \cdot m/s^2$
B. $N \cdot s$
C. $kg \cdot s/m$
D. N/s

24.

N
W E
S

positive

A 1.2 kg ball moving due east at 40 m/s strikes a stationary 6.0 kg object. The 1.2 kg ball rebounds to the west at 25 m/s. What is the speed of the 6.0 kg object after the collision?

neg.

A. 3.0 m/s
B. 13 m/s
C. 15 m/s
D. 65 m/s

$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$$

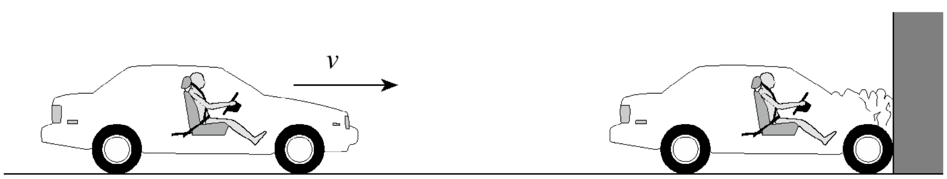
$$(1.2)(40) + 0 = (1.2)(-25) + 6\vec{v}_{2f}$$

$$48 = -30 + 6\vec{v}_f$$

$$v_f = \frac{78}{6} = 13 \text{ m/s East}$$

25.

The front of an automobile is designed to crumple in a collision in order to reduce the injury to the occupants. Discuss briefly the physics of how this design feature improves safety for the occupants. **(4 marks)**



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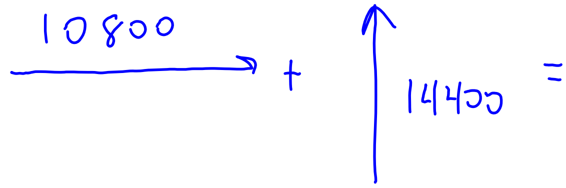
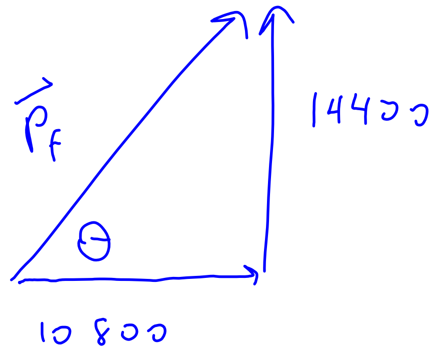
N
W E
S



9808
26.

A 900 kg car travelling at 12 m/s due east collides with a 600 kg car travelling at 24 m/s due north. As a result of the collision, the two cars lock together and move in what final direction?

A. 45° N of E
B. 53° N of E
C. 63° N of E
D. 69° N of E



$$\theta = \tan^{-1}\left(\frac{14400}{10800}\right)$$

$$\theta = 53^\circ \text{ N of E}$$

9901
27.

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

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

$$\vec{p} = (1000\ \text{kg})\left(\frac{60\ \text{km/h}}{3.6}\right) = 16700\ \text{kg m/s}$$

28.

positive

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

neg.

	MAGNITUDE	DIRECTION
A.	0.80 N · s ✗	Eastward ✗
B.	0.80 N · s ✗	Westward ✓
C.	3.2 N · s ✓	Eastward ✗
D.	3.2 N · s ✓	Westward ✓

$$\Delta\vec{p} = \vec{p}_f - \vec{p}_i$$

$$= (.08)(-25) - (.08)(15) = -3.2\ \text{N/s}$$

west

$m_1\vec{v}_{1i} = m_{both}\vec{v}_f$

9908

29. $v_f = \frac{m_1 v_{1i}}{m_{both}} = \frac{(40000)(2.5)}{70,000} = 1.4 \text{ m/s}$

A 40 000 kg rail car travelling at 2.5 m/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.

	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 ✓

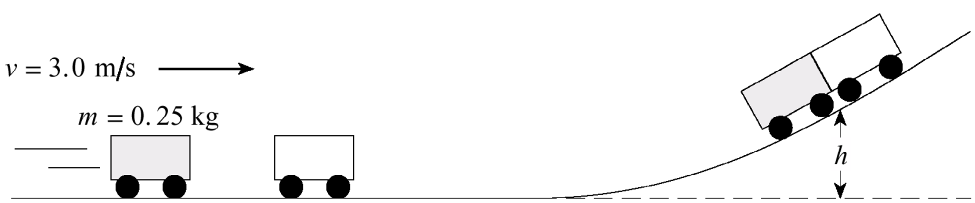
Now, check if KE is conserved.

$KE_i = \frac{1}{2} m_1 v_1^2 = 125000 \text{ J}$

$KE_f = \frac{1}{2} m_{both} v_f^2 = 68600$

KE Not conserved ∴ inelastic

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



To what height h do the combined carts travel up the hill? **(7 marks)**

$m_1\vec{v}_{1i} + m_2\cancel{\vec{v}_{2i}} = m_{both}\vec{v}_f \rightarrow \vec{v}_f = \frac{m_1 v_i}{m_{both}} = \frac{(.25)(3)}{.5} = 1.5 \text{ m/s}$

$\vec{v}_{2i} = 0$

Now, use energy!

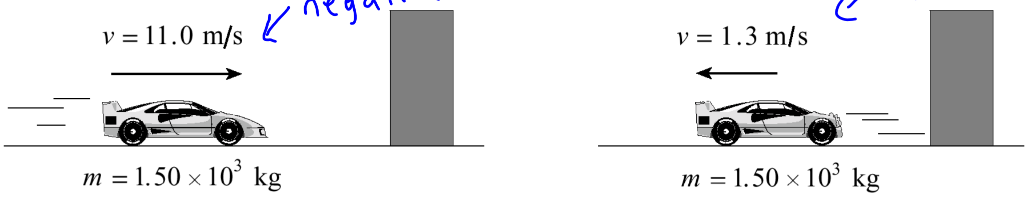
$KE_i + \cancel{PE_i} = \cancel{KE_f} + PE_f$

$\frac{1}{2}\cancel{m_{both}} v^2 = \cancel{m_{both}} g h_f \rightarrow h_f = \frac{v^2}{2g} = .11 \text{ m}$

0001

31.

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



The car rebounds 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?

A. 8.6×10^3 N
B. 1.1×10^4 N
C. 1.5×10^4 N
D. 1.8×10^4 N

$$\vec{F} = \frac{\Delta \vec{p}}{\Delta t} = \frac{m_1 v_f - m_1 v_i}{\Delta t}$$

$$\vec{F} = \frac{(1500)(1.3) - (1500)(-11)}{1.7} = 10850 \text{ N}$$

32.

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?

	SPEED	TYPE OF COLLISION
A.	9.4 m/s ✓	Elastic ✗
B.	9.4 m/s ✓	Inelastic ✓
C.	15 m/s ✗	Elastic ✗
D.	15 m/s ✗	Inelastic ✓

$$m_1 \vec{v}_{1i} + m_2 \underbrace{\cancel{\vec{v}_{2i}}}_{=0} = m_{both} \vec{v}_f \rightarrow \vec{v}_f = \frac{m_1 \vec{v}_{1i}}{m_{both}} = 9.4 \text{ m/s}$$

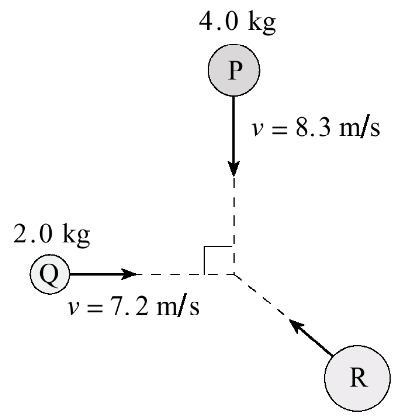
Is KE conserved?

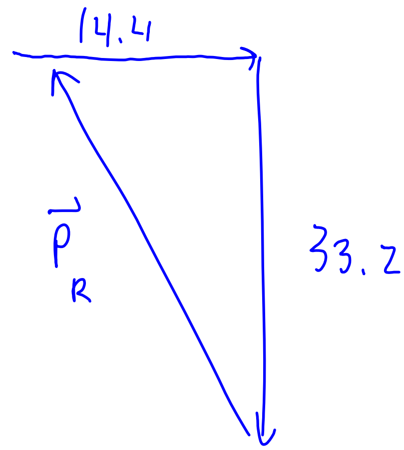
$$KE_i = \frac{1}{2}(1500)(25^2) = 468750 \qquad KE_f = \frac{1}{2}(4000)(9.4)^2 = 176,720$$

Not conserved

33.

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?

A. 19 kg · m/s
B. 30 kg · m/s
C. 36 kg · m/s
D. 48 kg · m/s

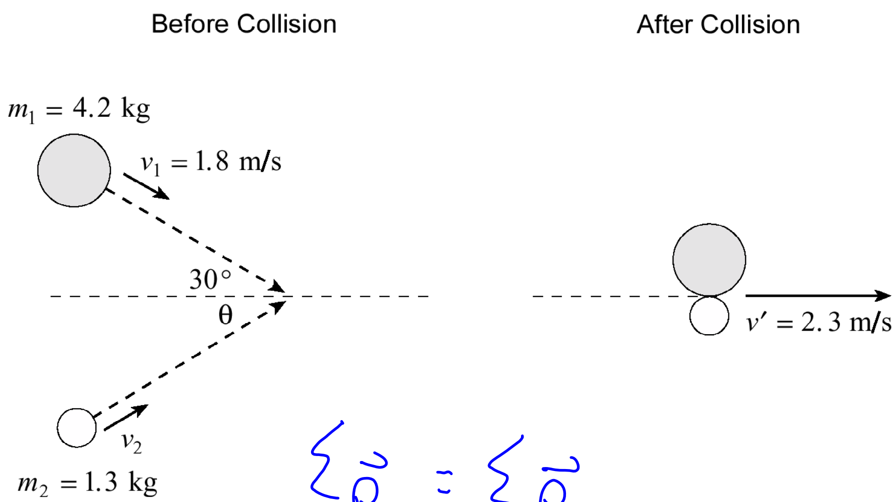
$$p_R^2 = 33.2^2 + 14.4^2$$

$$\vec{p}_R = 36.2 \text{ kg m/s}$$

0006

34.

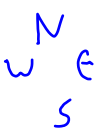
Two steel pucks are moving as shown in the diagram. They collide inelastically.

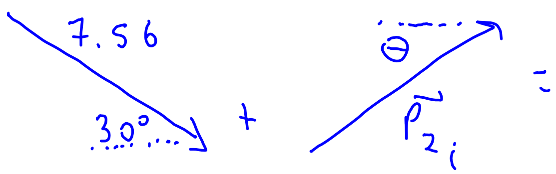


$$\sum \vec{p}_i = \sum \vec{p}_f$$

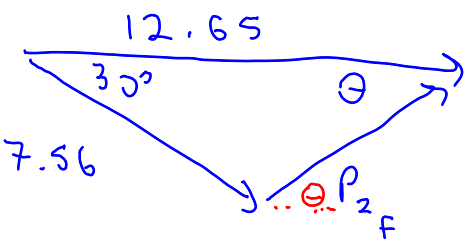
Determine the speed and direction (angle θ) of the 1.3 kg puck before the collision. **(7 marks)**

$$\vec{p}_{1_i} + \vec{p}_{2_i} = \vec{p}_{both_f}$$





$(5.5)(2.3) = 12.65$



$$P_{2_f}^2 = 12.65^2 + 7.56^2 - 2(12.65)(7.56)\cdot\cos 30°$$

$$P_{2_f} = 7.18 \text{ kg m/s}$$

$$\boxed{v_2 = \frac{7.18}{1.3} = 5.5 \text{ m/s @ } 32° \text{ N of E}}$$

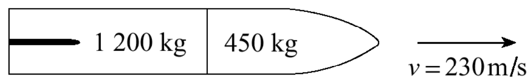
$$\frac{\sin\theta}{7.56} = \frac{\sin 30}{7.18}$$

$$\theta = \sin^{-1}\left(\frac{7.56 \sin 30}{7.18}\right)$$

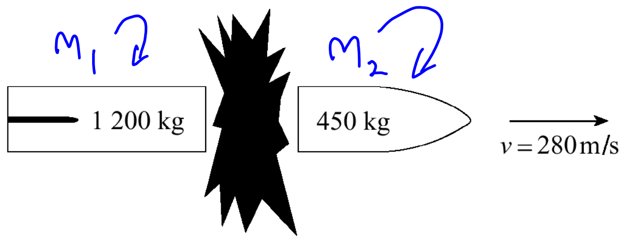
0008

35.

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



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



a) What was the momentum of the space vehicle before the explosion? **(2 marks)**

a) $\vec{p} = mv = (1650)(230) = 379500 = 3.8 \times 10^5 \ N \cdot s$

b) What was the magnitude of the impulse on the 1 200 kg part during the separation? **(3 marks)**

$\Delta p = \vec{p}_f - p_i$ need v_f →

$\Delta p = m_1 v_f - m_1 v_i$

$\Delta \vec{p} = (1200)(211) - 1200(230) = -2.2 \times 10^4$ kg m/s

$m_{both} \vec{v}_i = m_1 \vec{v}_{1_f} + m_2 \vec{v}_{2_f}$

$\vec{v}_{1_f} = \dfrac{m_{both} \vec{v}_i - m_2 \vec{v}_{2_f}}{m_1} = 211 \ m/s$

c) Using principles of physics, explain what changes occur, if any, to the

i) momentum of the system as a result of the explosion. **(2 marks)**

see answer key on last page

ii) kinetic energy of the system as a result of the explosion. **(2 marks)**

see answer key on last page

$\Sigma p_i = (1)(6) = 6$ $\quad\quad$ $\Sigma \vec{p}_f = 1(-2) + 2(4) = 6$

0101

36.

$\therefore$ momentum is conserved!

positive

A 1.0 kg cart moves to the right at 6.0 m/s and strikes a stationary 2.0 kg cart. After the head-on collision, the 1.0 kg cart moves back to the left at 2.0 m/s and the 2.0 kg cart moves to the right at 4.0 m/s. In this collision

neg.

$KE_i = \frac{1}{2}(1)(6)^2 = 18\ J$

A. only momentum is conserved.
B. only kinetic energy is conserved.
C. both momentum and kinetic energy are conserved.
D. neither momentum nor kinetic energy is conserved.

$KE_f = \frac{1}{2}(1)(-2)^2 + \frac{1}{2}(2)(4)^2 = 18J$

$\therefore$ KE is conserved

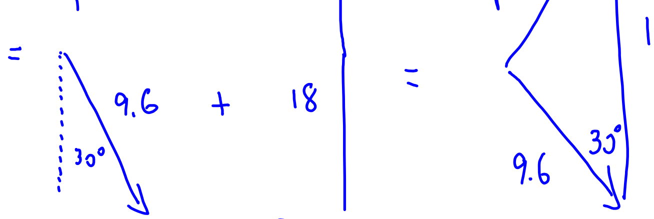
N W E S

37.

A 12.0 kg shopping cart rolls due south at 1.50 m/s. After striking the bumper of a car, it travels at 0.80 m/s, 30° E of S. What is the magnitude of the change in momentum sustained by the shopping cart?

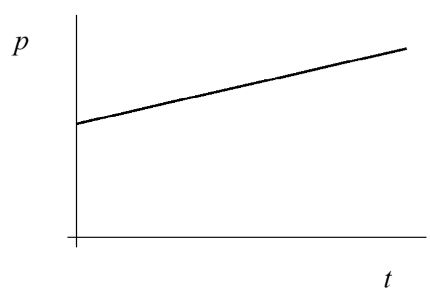
$\Delta\vec{p} = \vec{p}_f + -\vec{p}_i$

A. 8.4 kg · m/s
B. 9.7 kg · m/s
C. 11 kg · m/s
D. 27 kg · m/s



38. $\Delta p^2 = 18^2 + 9.6^2 - 2(18)(9.6)\cos 30$ $\quad$ $\Delta p = 10.8$ kg m/s

The graph below shows momentum, p, versus time, t, for a spacecraft while it is firing its rocket engines in space.



What does the slope of this graph represent?

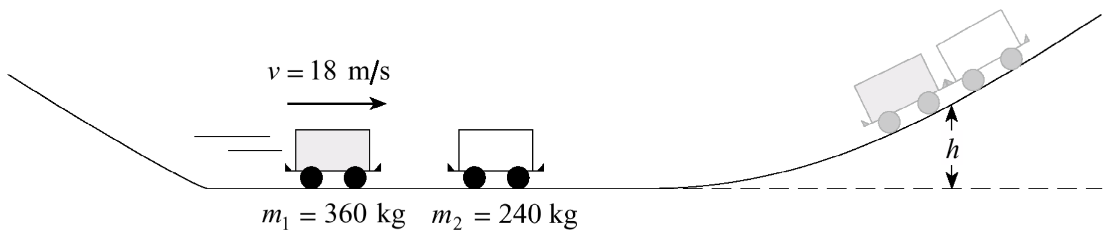
A. the mass of the spacecraft
B. the velocity of the spacecraft
C. the net force on the spacecraft
D. the work done on the spacecraft

slope $= \frac{p}{t}$

well... $F\Delta t = \Delta p \therefore \frac{p}{t} = F$

39.

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.) **(7 marks)**

$$\Sigma \vec{p}_i = \Sigma \vec{p}_f$$

$$\vec{p}_{1_i} + \underbrace{\cancel{\vec{p}_{2_i}}}_{=0} = \vec{p}_{both_f}$$

$$m_1 \vec{v}_{1_i} = m_{both} \vec{v}_f$$

$$v_f = \frac{m_1 v_{1_i}}{m_{both}}$$

$$v_f = \frac{(360)(18)}{600} = 10.8 \text{ m/s}$$

$$KE_i + \underbrace{\cancel{PE_i}}_{=0} = \underbrace{\cancel{KE_f}}_{=0} + PE_f \quad \leftarrow \text{after collision}$$

$$\frac{1}{2} \cancel{m} v_i^2 = \cancel{m} g h$$

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

$$h = 5.95 \text{ m}$$

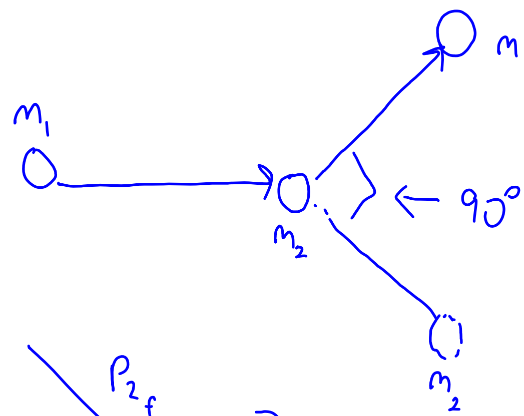
8501

40. A chromium nucleus of mass 52 amu moving at 26 m/s collides obliquely with an identical nucleus that is at rest, and the two nuclei move off at right angles to each other. The final speed of the incoming nucleus is 24 m/s. Determine the final speed of the target nucleus, and its direction of motion relative to that of the incoming nucleus.

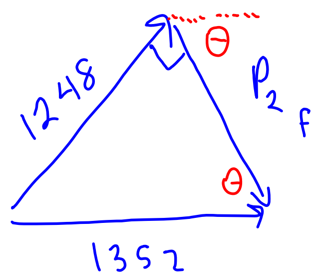
assume incoming nucleus is moving due east

$$\sum \vec{p}_i = \sum \vec{p}_f$$

$$\vec{p}_{1_i} + \underbrace{\cancel{\vec{p}_{2_i}}}_{=0} = \vec{p}_{1_f} + \vec{p}_{2_f}$$



$$\underbrace{(52)(26)}_{=1352} = (52)(24) + p_{2_f}$$



$$\sin\theta = \frac{1248}{1352} \rightarrow \theta = \sin^{-1}\left(\frac{1248}{1352}\right)$$

$$p_{2_f}^2 = 1352^2 - 1248^2$$

$$p_{2_f} = 520 \qquad \vec{v}_f = \frac{520}{52} = 10\ m/s\ @\ 67°\ S\ of\ E$$

9001
41.
An object of mass 0.092 kg which is initially at rest attains a speed of 75 m/s in 0.028 s. What average net force acted on the object during this time interval?

A. 1.2×10^2 N

B. 2.5×10^2 N

C. 2.8×10^2 N

D. 4.9×10^2 N

$\Delta \vec{p} = \vec{p}_f - \vec{p}_i = (.092)(75) - 0 = 6.9 \text{ kg m/s}$

$\vec{F} \Delta t = \Delta \vec{p}$

$\vec{F} = \frac{\Delta \vec{p}}{\Delta t} = \frac{6.9}{.028} = 246 \text{ N}$

8606
42. A ball strikes a wall perpendicularly with an initial speed of 4.0 m/s, bouncing off the wall at 4.0 m/s in the opposite direction. Which of the following statements correctly compares the ball's momentum and kinetic energy before and after the collision respectively?

momentum is a vector. Since direction changed, momentum is different

	Momentum	**Kinetic Energy**
A.	different ✓	different ✗
B.	the same ✗	the same ✓
C.	different ✓	the same ✓
D.	the same ✗	different ✗

Energy is a scalar, so direction is irrelevant

8606
43. A curling rock of mass 20.0 kg moving with a constant speed of 0.5 m/s collides obliquely with a stationary rock of the same mass. Immediately after the collision the first rock moves off at 0.3 m/s. If the collision is perfectly elastic, what is the speed of the second rock immediately afterwards?

KE is conserved, so use energy!

A. zero

B. 0.20 m/s

C. 0.30 m/s

D. 0.40 m/s

$\Sigma KE_i = \Sigma KE_f$

$\frac{1}{2} m_1 v_{1_i}^2 + 0 = \frac{1}{2} m_1 v_{1_f}^2 + \frac{1}{2} m_2 v_{2_f}^2$ ← since $m_1 = m_2$, masses cancel. So do the $\frac{1}{2}$'s

$v_{1_i}^2 = v_{1_f}^2 + v_{2_f}^2$

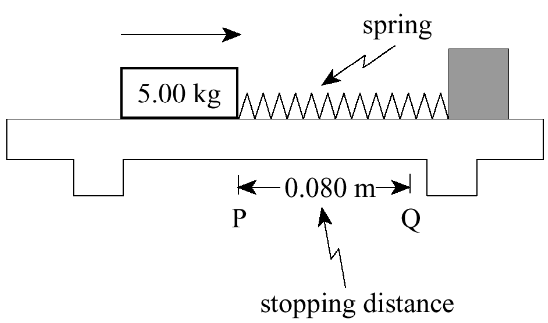
$0.5^2 = 0.3^2 + v_{2_f}^2$ $v_{2_f} = 0.40 \text{ m/s}$

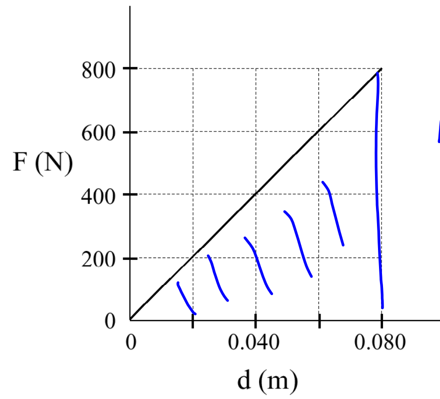
Scholarship Questions! Nasty, but really neat!

9401

44.

A 5.00 kg block, travelling along a horizontal, frictionless surface, collides head on with a spring. The block comes to a stop in 0.080 m. The stopping force exerted by the spring on the block increases from zero to 800 N as shown on the graph below. (Assume no energy loss due to heat.)





$A_\Delta = \frac{bh}{2} = \frac{(.08)(800)}{2}$

$= 32 J$

a) What was the speed of the block when it first touched the spring at point P? **(7 marks)**

b) What is the magnitude of the impulse exerted by the spring in stopping the block? **(3 marks)**

a) $W = \Delta KE$

area under graph $= \Delta KE$

$32 = 0 - \frac{1}{2} m v_i^2$ $\quad -v_f = \sqrt{\frac{2(32)}{5}} = 3.58 \ m/s$

b) $\Delta \vec{p} = \vec{p}_f - \vec{p}_i$

$\Delta \vec{p} = m v_f - m v_i$

$\Delta \vec{p} = 5(0) - 5(3.58) = -17.8 \ kg \ m/s$

N
W E
S

9406

45.

$m_1 = 2$ kg

$m_2 = 4$ kg

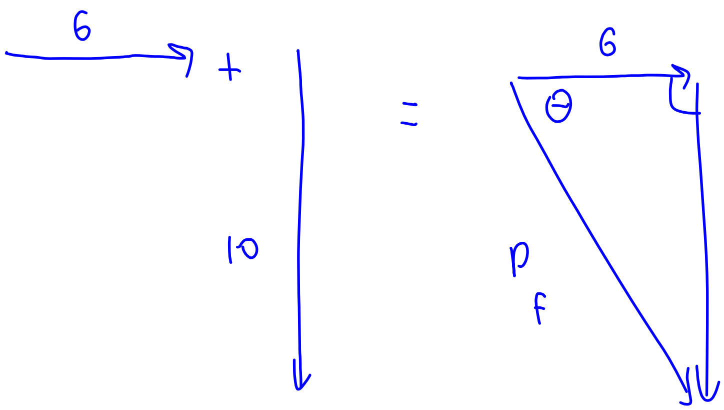
A 2.00 kg puck is sliding across a level frictionless table at 3.00 m/s towards the east. It collides with a second puck having a mass of 4.00 kg travelling at 2.50 m/s due south. The pucks stick together on impact. What is the magnitude of the change in momentum of the 2.00 kg puck during this collision?

(10 marks)

we need v_f of 2 kg puck

$\sum \vec{p}_i = \sum \vec{p}_f$

$\vec{p}_{1_i} + \vec{p}_{2_i} = \vec{p}_{both_f}$



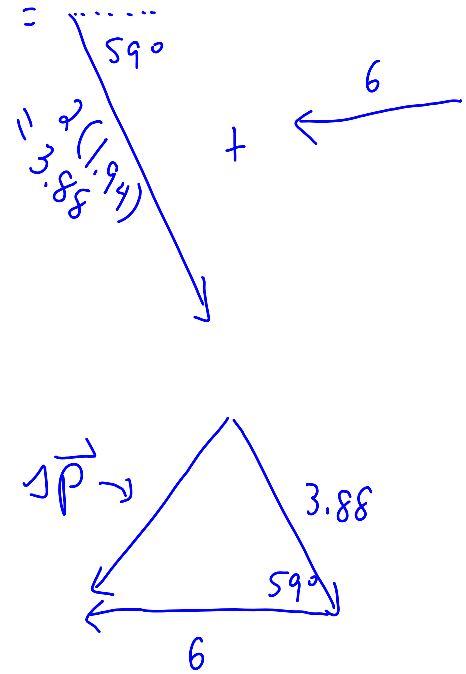
$p_f^2 = 6^2 + 10^2$

$\theta = \tan^{-1}(10/6)$

$p_f = 11.66$

$v_f = \frac{11.66}{6} = 1.94$ @ 59° S of E

$\Delta \vec{p} = \vec{p}_f - \vec{p}_i = \vec{p}_f + -\vec{p}_i$



$\Delta p^2 = 6^2 + 3.88^2 - 2(6)(3.88)\cos 59$

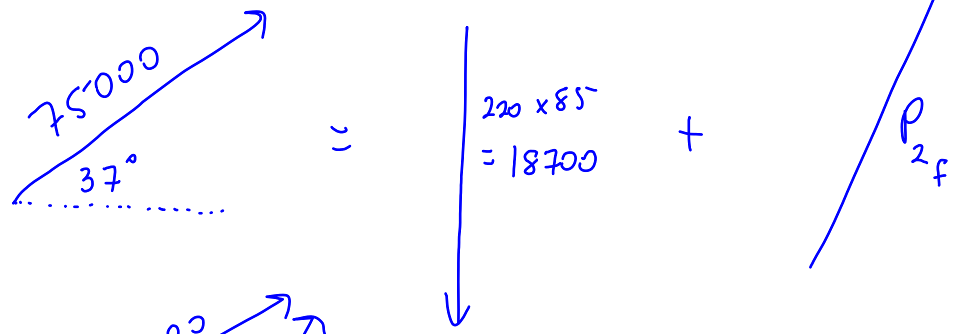
$\boxed{\Delta p = 5.2 \text{ kg m/s}}$

9508

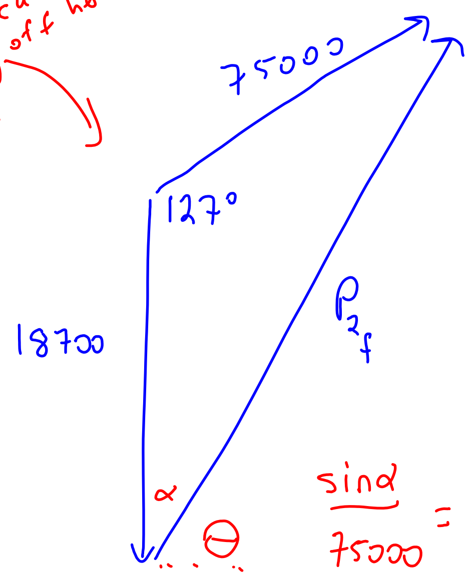
46.

A 300 kg projectile moving at 250 m/s at 37° above the horizontal explodes into two parts. The larger, 220 kg part moves downward with a speed of 85 m/s and hits the ground directly below the point of explosion. What maximum height above the point of explosion was reached by the smaller 80 kg part? (Assume g is a constant.) **(12 marks)**

$$\sum \vec{p}_i = \sum \vec{p}_f$$



my scale is way off here. oops.



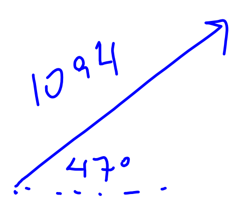
$$p_{2f}^2 = 75000^2 + 18700^2 - 2(75000)(18700)\cos 127$$

$$p_{2f} = 87537$$

$$v_{2f} = \frac{87537}{80} = 1094 \text{ m/s @ } 47° \text{ above horiz.}$$

$$\frac{\sin\alpha}{75000} = \frac{\sin 127}{87537}$$

$\alpha = 43°$ $\theta = 90 - 43$

Now, treat like a projectile: 

, find h_{max}

$$v_{y_i} = 1094 \sin 47 = 800 \text{ m/s}$$

$v_{y_f} = 0$ $a = -9.8$

$$v_f^2 = v_i^2 + 2ad \rightarrow d = \frac{v_f^2 - v_0^2}{2a} = \frac{-(800^2)}{2(-9.8)} = 32,650 \text{ m}$$

$d = 3.26 \times 10^4$ m Wow, tough question!

8506

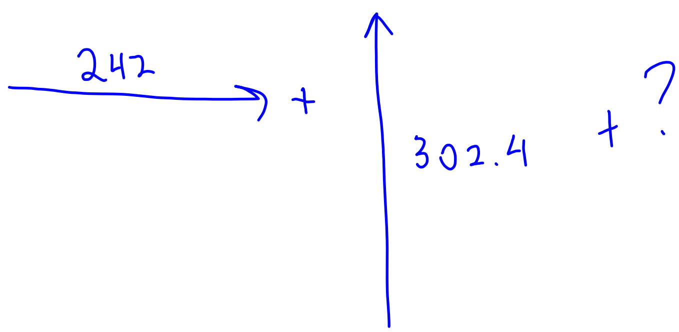
47.

A stationary life raft of mass 160 kg is carrying two survivors with masses of 55 kg and 72 kg, respectively. They dive off the raft at the same instant, the 55 kg person due East at 4.4 m/s and the 72 kg person due North at 4.2 m/s. At what speed and in what direction does the raft start to move? **(10 marks)**

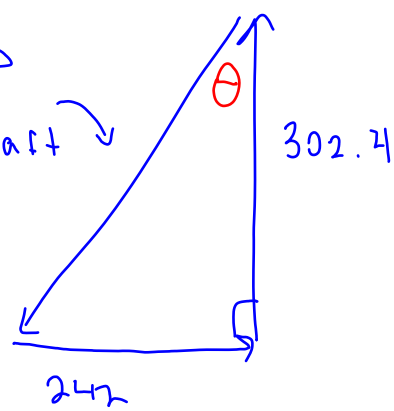
N
W E
S

$$\sum \vec{p}_i = \sum \vec{p}_f$$

$$0 = \vec{p}_{55} + \vec{p}_{72} + \vec{p}_{raft}$$



$\theta = \tan^{-1}\left(\frac{242}{302.4}\right)$ $\vec{p}_{raft}$



$$p_{raft} = \sqrt{242^2 + 302.4^2}$$

$$p_{raft} = 387.3 \text{ kgm/s}$$

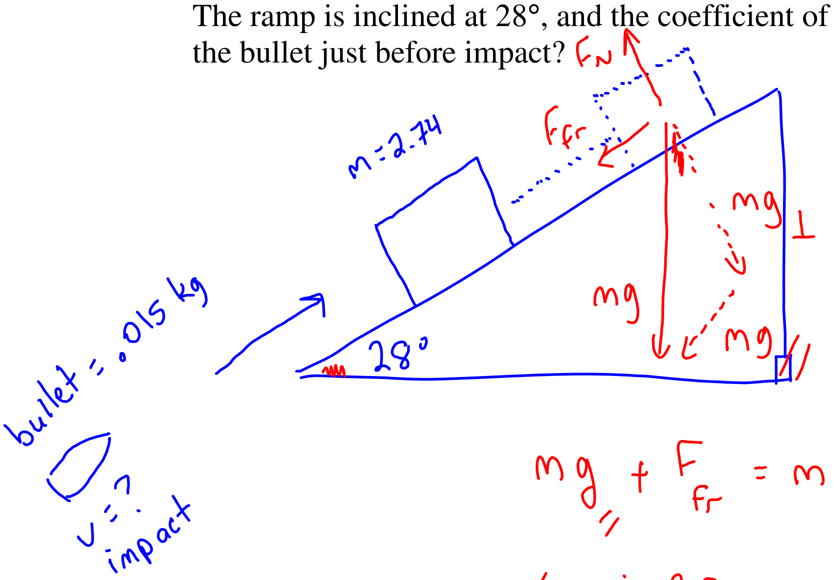
$$v_{raft} = \frac{387.3}{160} = 2.4 \text{ m/s @ } 39^\circ \text{ W of S}$$

or 51° S of W

8906

48.

A 15 g bullet traveling parallel to an inclined ramp strikes a 2.74 kg block of wood and becomes imbedded in it. The impact drives the block a distance of 26 cm up the ramp. The ramp is inclined at 28°, and the coefficient of friction is 0.40. What is the speed of the bullet just before impact? **(10 marks)**



We need v of block just after collision. Call it v_i

$$mg_{//} + F_{fr} = ma \rightarrow mg_{//} + \mu mg_{\perp} = ma$$

$$\cancel{m}g\sin 28 + \mu \cancel{m}g\cos 28 = \cancel{m}a$$

$$a = g\sin 28 + \mu g\cos 28 = 8.06\ m/s^2$$

$a = 8.06\ m/s^2 \quad v_f = 0 \quad d = .26 \quad v_i = ?$

$$v_f^2 = v_i^2 + 2ad \rightarrow v_i = \sqrt{v_f^2 - 2ad}$$

$$v_i = \sqrt{0 - 2(-8.06)(.26)} = 2.05\ m/s$$

slowing down

So, the velocity after the collision is 2.05 m/s.

Now, use momentum!

$$\vec{p}_{bullet} = \vec{p}_{both}$$

$$m_{bullet} v_{impact} = m_{both}(2.05) \rightarrow v_{impact} = \frac{(2.74 + .015)(2.05)}{.015}$$

$$\boxed{V = 380\ m/s}$$

9106 m_1 m_2

49. A 1.3 kg object is moving due East at 25 m/s on a frictionless, horizontal surface. When the first object strikes a second, stationary 4.8 kg object, the 1.3 kg object rebounds at 9.0 m/s in a direction 53 degrees north of west. What percentage of the original kinetic energy of the system is converted into other forms of energy during the collision?

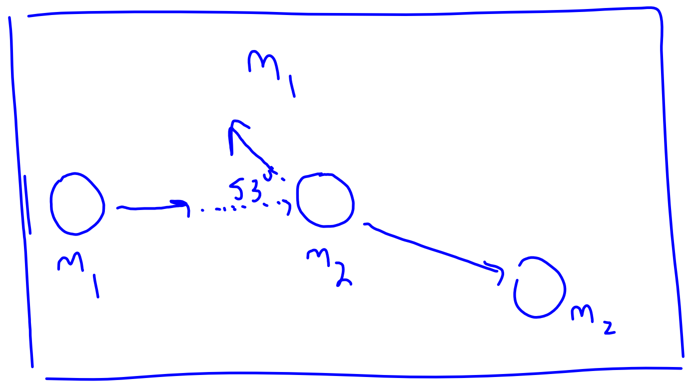
N W E S

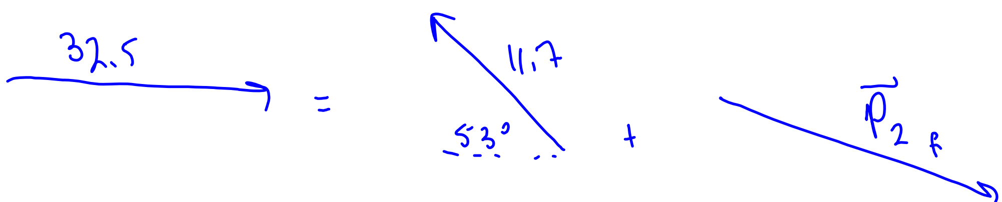
(10 marks)

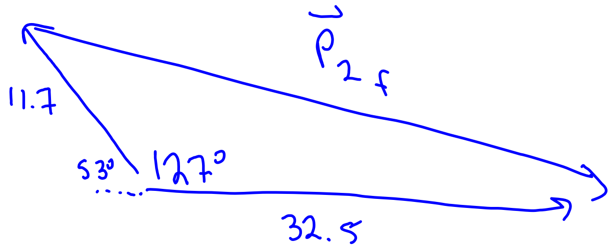
We need v_f of 4.8 kg object

$$\sum \vec{p}_i = \sum \vec{p}_f$$

$$\vec{p}_{1_i} + \underbrace{\cancel{\vec{p}_{2_i}}}_{=0} = \vec{p}_{1_f} + \vec{p}_{2_f}$$







$$p_{2_f}^2 = 11.7^2 + 32.5^2 - 2(11.7)(32.5)\cos 127$$

$$p_{2_f} = 40.63 \text{ kg m/s}$$

$$v_{2_f} = \frac{40.63}{4.8} = 8.46 \text{ m/s}$$ (I don't need direction, since the rest of the question is energy)

$$\text{Total } KE_i = \frac{1}{2} m_1 v_{1_i}^2 = \frac{1}{2}(1.3)(25)^2 = 406.25 \text{ J}$$

$$\text{Total } KE_f = \frac{1}{2} m_1 v_{1_f}^2 + \frac{1}{2} m_2 v_{2_f}^2 = \frac{1}{2}(1.3)(9)^2 + \frac{1}{2}(4.8)(8.46)^2 = 224.4$$

$406.25 - 224.4 = 181.8$ J of energy lost $\quad \frac{181.8}{406.25} = 44.8\%$

Answers:

1. a
2. $\Delta KE = 24.1$ J
3. Conservation of momentum is a vector concept. Both gliders have same mass and same speed, so the magnitude of their momentum is the same, but their direction is opposite. One glider has a momentum of +p, one glider has a momentum of –p, so the total momentum before impact is zero. After the collision, the momentum is still zero, so momentum has been conserved, and no momentum has been lost.
4. b
5. a) i) v= 1.1 x 10^2 m/s
   ii) $\Delta p = 3.0\times10^4$ N•s
   b) Impulse is a change in momentum. Since momentum is conserved, the momentum gained by the probe must equal the momentum lost by the capsule.
6. d
7. a
8. d
9. a
10. a
11. d
12. d
13. b
14. $v = 2.1\,m/s, \theta = 47^\circ$
15. a
16. m_2=4.19 kg
17. d
18. d
19. a) h=1.3 m
    b) The same height
    c) Energy is a scalar, so the steepness of the slope is irrelevant. All of the kinetic energy will be transferred to potential energy in both cases, and since both cases have the same initial kinetic energy, the final potential energy will also be the same, and so will the final height.
20. c
21. b
22. $v = 56\,m/s$ @ 42° N of E
23. b
24. b
25. $\Delta KE = F\bullet d$ and as d increases, F decreases.
    $\Delta p = F\Delta t$, and as Δt increases, F decreases.
    Both the increase in time of impact and increase in distance of impact lower the force transferred to the occupants.
26. b
27. b
28. d
29. b
30. h=0.11 m
31. b
32. b
33. c
34. $v = 5.5\,m/s, \theta = 32^\circ$
35. a) 3.8 x 10^5 kg m/s
    b) $\Delta p = 2.3\times10^4\,N\cdot s$
    c)i) in an explosion, momentum is conserved, so no change
    ii) the explosion adds kinetic energy to the system, so the system will gain kinetic energy

36. c
37. c
38. c
39. h= 6.0 m
40. $v = 10\, m/s$ @ 67° S of E
41. F = 246 N
42. c
43. d
44. a) v=3.6 m/s b) 18 kg m/s
45. $\Delta p = 5.20$ kg m/s
46. d= 3.25×10^4 m
47. $v = 2.4\, m/s$ @ 51° S of W
48. v= 3.8×10^2 m/s
49. 44.8%