P30 Unit A Momentum Review Package

1. An 80 kg skier initially travelling at 6.0 m/s exerts a net sideways force of 40 N for 1.3 seconds.

   a) What is the impulse on the skier caused by the force?
   (2 mark)

   b) What will be the change in momentum? (1 mark)

   c) What will be the acceleration of the skier due to the sideways force?
   (2 mark)

   Suggested Response

   a) Impulse = $\vec{F}\,t$ = 40 N x 1.3 s = 52 N • s sideways

   b) $\Delta\vec{p}$ = impulse = 52 N • s sideways

   c) $\vec{a} = \frac{\overrightarrow{F_{net}}}{m} = \frac{40\text{ N}}{80\text{ kg}}$ = 0.50 m/s^2 sideways

2. While playing tennis Herman returns a 70 km/h serve at 63 km/h. If the 0.098 kg tennis ball was in contact with racket for 8.0 ms (milli = 10^{-3}) what was the force applied to the ball expresed in scientific notion b x 10^{w}. The value of b is
   ________________.
   (Round and record your answer to three digits.)
   Δp=mΔv=FΔt
   F= 0.098 kg x (17.5 - $^{-}$19.4)m/s
   F=0.45 kN

3. The 1300kg Drop of Doom at W.E.M drops for 20 m and reaches 19.8 m/s. If it takes 2.1 s for the ride to stop at the bottom, what is the braking force applied to stop the ride?
   (assume for this question that there is no friction)
   A. 445 kN
   B. 894 N
   ✓C. 12.3 kN
   D. 7.55 kN

   7848 / 9.81 m/s^2 = 800 kg
   mgh = 1/2 mv^2
   v^2 = 2gh = 2 x 9.81 m/s^2 x 20 m
   v= 19.8 m/s
   Δp =mΔv = FΔt
   (1300 kg 19.8 m/s) / 2.1 s = F= 12.3 kN

4. A 0.240 kg ball moving at 32.0 m/s strikes a brick wall perpendicularly and rebounds with a speed of 28.0 m/s. The wall received an impulse of
   Round and record your answer to three digts
   Δp=mΔv
   Δp=0.24 kg x (32+28)m/s
   Δp=14.4 Ns

5. At West Edmonton Mall, a 200 kg roller coaster cart travelling at a speed of 3.0 m/s hits and couples to an additional two identical stationary carts. Calculate the speed of the three carts travelling together assuming negligible friction.
(3 marks)
pbefore=pafter
$mv_{original}=3mv_{final}$
$v_{final}=3.0m/s / 3$
$v_{final}= 1.0$ m/s

USE THIS INFORMATION TO ANSWER THE NEXT 3 QUESTIONS

During the war of 1812 large cannons were used to smash down the walls of forts and destroy enemy ships. These cannons were made from large of amounts of cast iron and were moved from place to place by teams of horses. The cannon itself often had a mass of 3000 kg and fired 10 kg balls distances of up to a kilometer. The cannon ball was propelled from the cannon by an explosion of gun powder. The explosion gave the cannon ball an initial velocity of 200 km/h which was achieved just before the ball left the barrel. It was not until WW I that a more effective long range weapon was developed.

6. What is the force on the cannon ball if it takes 0.021 seconds for the ball to reach the end of the barrel ?
Put abcd into answer sheet
answer a.bc x 10^{d}
$P=m\Delta v = F\Delta t$
F = 10 kg x 55.5 m/s / 0.021
F = 2.65 x 10^{4} N

7. What is the recoil velocity of the cannon in km/h
A. 1.50 km/h
✓B. 0.667 km/h
C. 1.21 km/h
D. 1.33 km/h
A)
$mv_{c} = mv_{cb}$
3000 kg x v = 10 kg x 200 km/h
v_{c} = 0.667 km/h

8. If a 7.0 kg Confederate cannon ball at 180 km/h collided in mid air with a 10 kg Yankee cannon ball moving at 200 km/h. If the Confederate ball was deflected straight down with a velocity of 70 km /h, what is the resulting velocity of the Yankee cannon ball?
(assume that both balls were traveling parallel to the Earth when they collided)
(8 marks)

Pbx = Pax
Pbx =200 km /h x 10 kg
+ (-180 km/h x 7)kg
Pbx = 740 kg km/ h
Pby = 0
Pay = 0
Pccbya = -70 km/h x 7 kg
= -490 km kg /h

Pyycba = + 490 km kg /h
Pxycba = 740 kg km/ h
Prycba = 888 kg km/ h
Tan ø = 490 kg km/ h / 740 kg km/ h
ø = 33. 5º above the horizon
P = mv
v = 888 kg km/ h / 10 kg
v = 88.8 km /h or 25 m/s

9. A 3.1 kg ball moving west to east struck a 2.0 kg stationary ball. If the 3.1 kg ball slowed to 1.2 m/s and was deflected to 25º north of east and the 2.0 kg ball was deflected to 48º south of east with a velocity of 1.06 m/s. What was the original velocity of the 3.1 kg ball?
(4 Marks)

$$p_{xbefore} = p_{xafter}$$

$$m_{1x}v_{1x} + m_{2x}v_{2x} = m_{1x}v'_{1x} + m_{2x}v'_{2x}$$

$$3.1kg \cdot v_{1x} + 0 = 3.1kg \times (\cos 25^{o} \times 1.2m/s) +$$

$$2.0kg \times \cos 48^{o} \times 1.06m/s$$

$$v_{1x} = 1.55m/s$$

10. A space ship travelling between Mars and Jupiter needs to change its speed of 1.83 km/s to 1.89 km/s. Its mass is 20 tonnes. (1 t = 1 Mg or 1000 Kg)

a) What is the impulse required?

b) It has two impulse engines... (not a warp engine) a small one with a thrust of 500 N and the large one has a thrust of 3.0 kN. How long would you have to burn the engines to obtain the impulse required to affect the change in momentum (velocity) described above?
6 marks

Δp=mΔv
Δp = (20t x 1000kg/t) x (1.89 - 1.83) km/s x 1000 m/km
Δp= 1.20 x 10^6 Ns

Δp=FΔt
Δt = Δp / F
Δt = 1.20 x 10^6 Ns / 3.5 x 10^3 N
Δt = 343 s

11. While playing tennis Herman returns a 70.0 km/h serve at 63 km/h in the opposite direction. If the 0.0980 kg tennis ball was in contact with racket for 8.00 ms (milli = 10^{-3}) what was the force applied to the ball?
(4 marks)

$$\textbf{Impulse} = \Delta p = m(v_f - v_i)$$

$$\Delta p = 0.098kg(17.5m/s - 19.4m/s)$$

$$\Delta p = 3.6Ns$$

$$\Delta p = F\Delta t$$

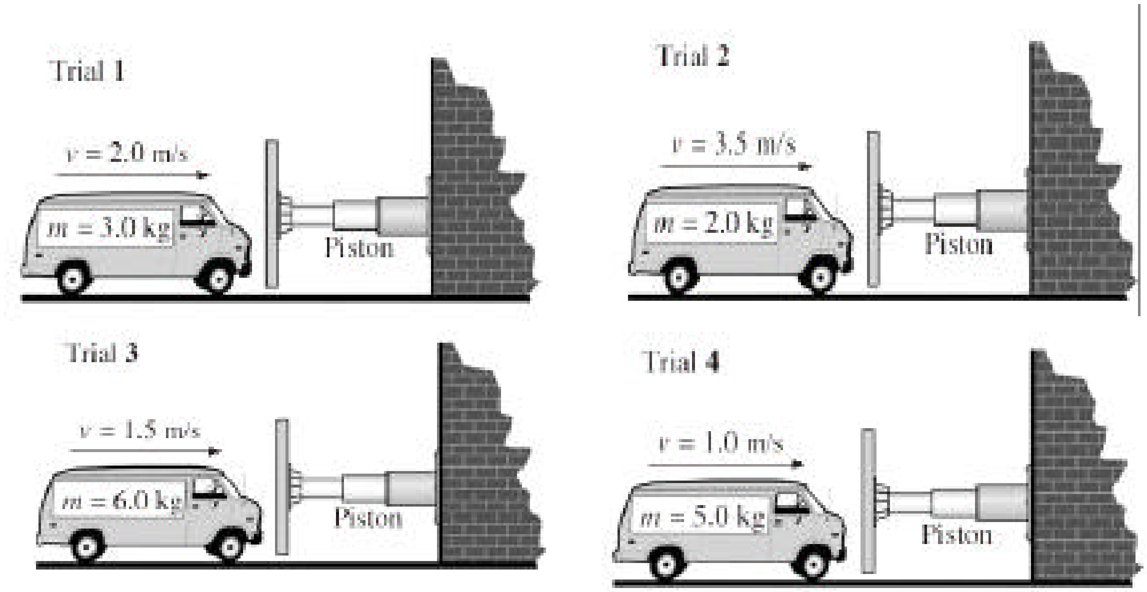
$$F = \frac{3.6Ns}{8.0 \times 10^{-3}s}$$

$$F = 452\ N$$

12. If a 2 000 kg car moving 20.0 m/s collides with a bridge abuttment and stops in 0.0550 s. What was the force of the collision?
A. 2.20 kN
✓B. 727 kN
C. 100 kN
D. 5.5 kN
FΔt = mΔv
F= 2000 kg x 20 m/s / 0.055 s
F= 727 kN

13. **Numerical Response**

A student performs an experiment to investigate the time required to stop a toy van. In each of four trials, the student varies the speed and mass of the van. The toy van is brought to rest by a piston that applies a uniform force that is the same for each trial.



When the trials above are listed in order from the trial that has the longest stopping time to the trial that has the shortest stopping time, the order is __________, __________, __________, and __________.

(Record all four digits of your answer in the numerical-response section on the answer sheet.)

$F\Delta t = m\Delta v$

$\Delta t = m\Delta v / F$

Δt_3 = 9 Ns

Δt_2 = 7 Ns

Δt_1 = 6 Ns

Δt_4 = 5 Ns

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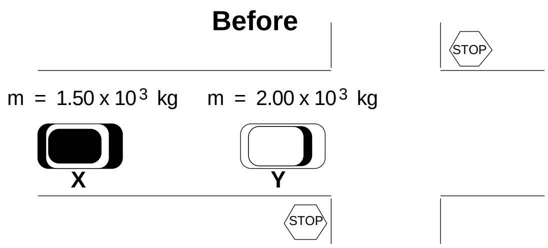
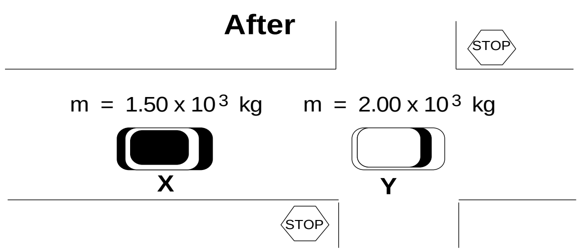
14. For vehicles that become stuck in snow or mud, a chain of fixed length, or a nylon tow rope that stretches, is often used to recover the stuck vehicle. When the stuck vehicle is being pulled, its change in momentum will

A. decrease over a shorter time when the chain is used
✓B. increase over a longer time when the tow rope is used
C. decrease over a longer time when the tow rope is used
D. increase over a longer time when the chain is used
B

A police officer's investigation of an accident involving a collision between vehicles X and Y provided the following information:



1.a test on the road surface with a 2.00×10^3 kg vehicle showed that the vehicle slowed down at the rate of $5.00\ m/s^2$ due to friction
2.each vehicle, X and Y, received some damage
3.after impact, vehicle Y travelled 19.6 m before stopping
4.vehicle X did not have the brakes applied before the collision
5.vehicle Y was stationary before the collision
6.vehicle X was stationary after the collision



15. What was the speed of vehicle Y just after the collision?
A. 1.56 m/s
B. 19.6 m/s
✓C. 14.0 m/s
D. 11.0 m/s

16. Immediately before the collision, the speed of vehicle X in m/s was expresed in scientific notion b x 10^{w}. The value of b is __________.
(Round and record your answer to three digits.)
1.87×10^1

17. In analyzing the scene of the accident, the officer most often applied her understanding of
✓A. the Law of Conservation of Momentum
B. Newton's First Law
C. Newton's Second Law
D. the Law of Conservation of Energy

18. Herman's 1500 kg car moving at 90 km/h to the west hits Alice's 2250 kg truck head on, when she was moving at 110 km/h to the east. If Alice's truck slows to 30 km/h after the collision what happened to Herman's car?
(4 marks)
$m_H v_H + m_A v_A = m_H v_H' + m_A v_A'$
1500 kg x -90 km/h + 2250 kg x 110 km/h = 2250 kg x 30 km/h + 1500 kg x v_H
v_H= 30 km/h

19. A 11.0 g bullet is fired from a 2.4 kg rifle with a velocity 329 m/s. What is the resulting velocity of the rifle?
(3 Marks)
$m_b v_b + m_r v_r = m_b v_b' + m_r v_r'$
$0 + 0 = 0.010$ kg x 329 m/s + 2.4 kg x v_r'
$v_r' = -1.5$ m/s

20. **Numerical Response**

A 90.0 kg running back hits a stationary 140 kg lineman at 8.30 m/s, and the lineman holds onto the running back. The magnitude of their velocity after the contact is______________ m/s.
(round and record your answer to 3 digits)

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$$
$$90 kg \times 8.3 m/s + 140 kg + 0 m/s =$$
$$(90 kg + 140 kg) v'$$
$$v' = 3.3 m/s$$

21. A 200 g toy car moving at 6.0 m/s North hits a 300 g toy truck moving North at 2.0 m/s. After the collision the toy truck travels 4.0 m/s North.

Calcuate the velocity of the dinky car after the collision.
A. 0 m/s
✓B. 3.0 m/s
C. 6.0 m/s
D. 4.0 m/s
pb=pa
(0.2 kg x 6.0 m/s) + (0.3 kg + 2.0 m/s) = (0.2 kg x v_{car}) + (0.3 kg +4.0 m/s)
v_{car}= 3.0 m/s

22. Jim, a student of Ross shep., is the first person to travel to Mars. Once there he goes for a space walk. He realizes that his control pack is not functioning properly so remembering his Physics 30 course takes off his space pack and throws it away from the spaceship so that he will be forced towards the ship. The space pack has a mass of 50 kg. He has a mass of 200 kg (without the pack). If initially he and the pack are at rest compared to the shjp and he reaches the spacecraft with a speed of 10 m/s

A) Find the force with which he pushed the pack away from him if he applied the force for 1.5 s.
B) Determine the velocity of the pack.

5 marks

$F\Delta t = m\Delta v$
F= 200kg x 10m/s / 1.5m/s
F=1.3 x 10^3 N

v = 40 m/s

23. A 150 kg man sits in a 250 kg stationary boat in which there is also a 25 kg rock. The man throws the rock out of the back of the boat with a velocity of 20 m/s. Calculate the velocity of the boat with the man in it now.
A. 2.0 m/s
B. 1.0 m/s
C. 3.33 m/s
✓D. 1.25 m/s

24. In a railroad yard, a 5.0 x 10^4 kg freight car travelling at 4.0 m/s east collides "head on" with a stationary tanker car, having a mass of 6.0 x 10^4 kg. If the two cars stick together, the final speed of the cars is

✓A. 1.8 m/s east
B. 0.40 m/s east
C. 4.8 m/s east
D. 3.3 m/s east

25. A 400 kg cannon with a 1.5 m long barrell sits on a frictionless rails and fires a 10 kg shell horizontally with a speed of 100 m/s.

A) Find the recoil speed of the cannon.
B) What is the impulse givin to the cannon ball?
C) What is the average force on the cannon ball while in the barrel, if it takes only 0.030s for it to reach the end of the barrel?
(remember that the cannon ball reaches maximium velocity at the end of the barrell)

Pb = Pa
0 = 400 kg x v + 10 kg x100m/s
v_{cannon} = -2.5 m/s
Δp =mΔv
Δp = 10kg x 100 m/s
Δp = 1.0 kNs

FΔt = mΔv
F = 1.0 kNs /0.030s
F= 33.3 kN

26. A 1000 kg cannon with a 5.0 m long barrell sits on a frictionless rails and fires a 10 kg ball horizontally with a speed of 500 m/s.

A) Find the recoil speed of the cannon.
B) What is the impulse givin to the cannon ball?
C) What is the average force on the cannon ball while in the barrel, if it takes only 0.020s for it to reach the end of the barrel? (remember that the cannon ball reaches maximium velocity at the end of the barrell)

Pb = Pa
0 = 1000 kg x v + 10 kg x 500m/s
v_{cannon} = -5.0 m/s

Δp =mΔv
Δp = 10kg x 500 m/s
Δp = 5.0 kNs

FΔt = mΔv
F = 5.0 kNs /0.020s
F= 250 kN

27. Alice is traveling west in her (1300 kg) car at 100 km/h and hits Herman who is traveling south at 140 km/h in his 800 kg car. If the cars hit and stick together in the inelastic collision, how far will the two cars slide after they hit, if there is a constant force due to friction of 20 kN after the collision,

Explain in simple terms how the problem was solved as you solved it
(8 marks)

$m_A v_{Ax} + m_H v_{Hx} = (m_A + m_H)\, v_{HAx}{}'$

Px after the collision is 3.61×10^{04} Ns

$m_A v_{Ay} + m_H v_{Hy} = (m_A + m_H) v_{HAy}$

Py = 3.1×10^{4}

use pythagoras

Pr = 4.77×10^{4} Ns @ 40.7º south west

P = mv

v = 22 m/s @ 40.7º south west

KE = W

$1/2\, mv^2 = Fd$

when the kinetic energy of the cars is used up the car will stop. Therefore solve for d

27.1 m @ 40.7º south west from the point of contact

28. After measuring and evaluating skid marks, police were able to determine that Car #1, of mass 765 kg, was travelling at 70.0 km/h at 57º N of W just after the impact. Car #2, of mass 1100 kg, was determined to be moving at 41.0 km/h at 44º N of W just after impact. In analyzing this accident scene, it is important for police to establish the velocity of each car just before impact.

- Describe in detail the physics concepts the police investigator would use to determine the speeds of the cars

- Calculate the speeds of the two cars just as they make contact.

8 marks

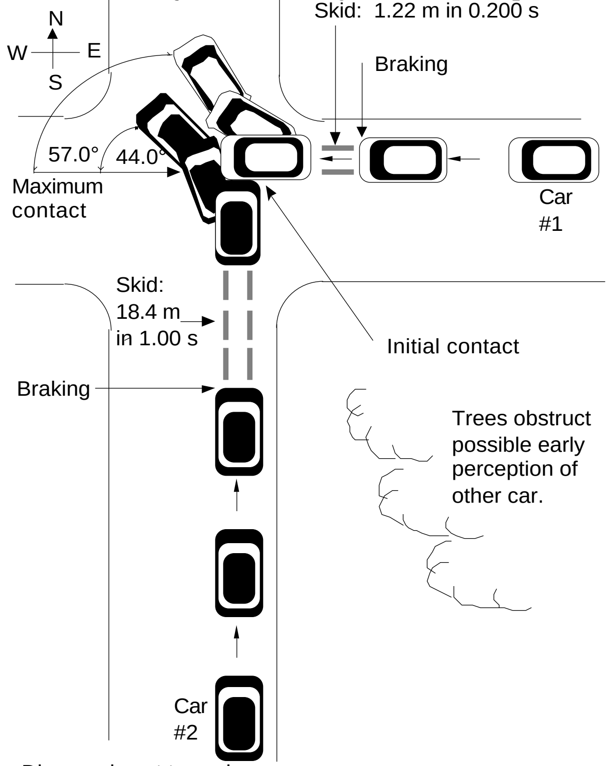


Diagram is not to scale.

Momentum is conserved.

∑pvertical = ∑ (pvertical car 1 + pvertical car 2)

∑phorizontal = ∑(phorizontal car 1 + phorizontal car 2)

Car 1: p = mv = (765 kg)(70.0 km/h)= 5.36 x 104 kg•km/h
Car 2: p = mv = (1100 kg)(41.0 km/h) = 4.51 x 104 kg•km/h

Car 1:
phorizontal = (cos 57.0°)(5.36 x 104 kg•km/h) = 2.92 x 104 kg•km/h
pvertical = (sin 57.0°)(5.36 x 104 kg•km/h) = 4.49 x 104 kg•km/h

Car 2:
phorizontal = (cos 44.0°)(4.51 x 104 kg•km/h) = 3.24 x 104 kg•kg/h)
pvertical = (sin 44.0°)(4.51 x 104 kg•km/h) = 3.13 x 104 kg•km/hr

Add momentum from car 1 and car 2
Total horizontal = 61607.6 kg•km/h
Total vertical = 76239.9 kg•km/h

All horizontal is due to Car 1
v = f(p,m) = f(61607.6 kg•km/h,765 kg) = 80.5 km/h
All vertical is due to Car 2 \
v = f(p,m) = f(76239.9 kg•km/h,1100 kg) = 69.3 km/h

29. A 2000 kg truck moving Northbound at a velocity of 50 km/h hits a small car of mass 1000 kg travelling at a velocity of 10 km/h Eastbound. Find the velocity of the wreckage given that the vehicles remain locked.
5 marks
px=1000kg x 10km/h=1.0 x 10^4 kgkm/h
px=2000kg x 50km/h=1.0 x 10^5 kgkm/h
pr√((1.0 x 10^5 kgkm/h)^2+(1.0 x 10^4 kgkm/h)^2
pr=1.004 x 10^5 kgkm/h
v = 1.004 x 10^5 kgkm/h / 3000kg
v = 33 km/h
tan ø = 1.0 x 10^4 kgkm/h / 1.0 x 10^5 kgkm/h
ø= 5.7º E of N

30. A)
A stationary rock explodes into four pieces. After the explosion a 2.0 kg piece moves west at 5.0 m/s. A 5.0 kg piece moves north at 8.0 m/s. A 1.0 kg piece moves east at 40 m/s. Calculate the mass of the missing piece if its speed is 25 m/s.

B)
If the explosion released 10 kJ of energy, what percentage ended up as kinetic energy?

7 marks
A)
Px = mv + mv
px = 2.0 kg x 5.0 m/s + 1.0 kg x -40m/s
px= -30 Ns
py= 5.0 kg x 8.0 m/s
py=40 Ns
pr=√((30Ns)^2 + (40Ns)^2)
pr=50Ns
m=pr / v
m= 50Ns / 25m/s
m= 2.0 kg

B) Ekt = 1/2 x 2.0 kg x (5.0m/s^2) + 1/2 x 5.0 kg x (8.0m/s^2) + 1/2 x 1.0 kg x (40m/s^2) + 1/2 x 2.0 kg x (25.0m/s^2)
Ekt = 25 J + 160 J + 800 J + 625 J
Ekt = 1610 J

% = 1610 J / 10 000 J x 100
% = 16 %

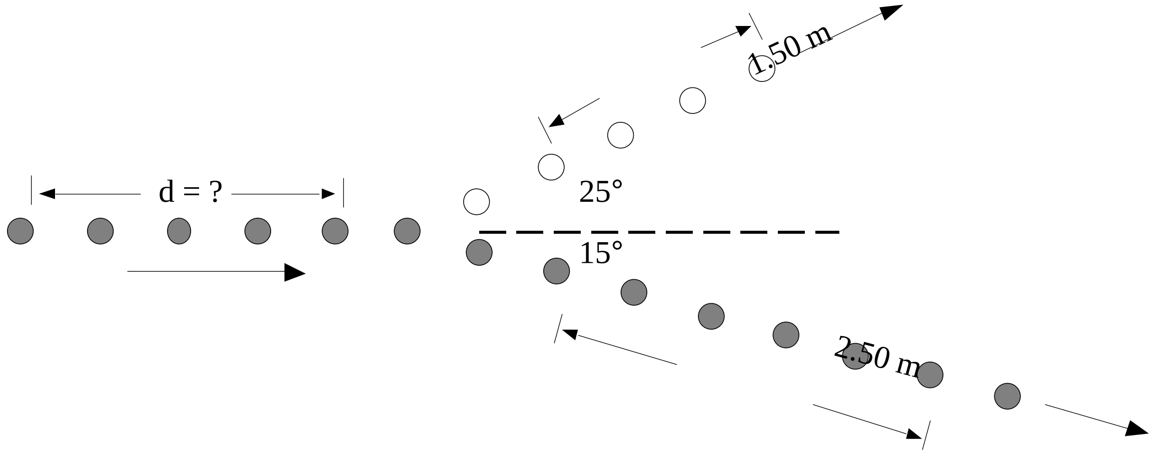
31. A 1200 kg cannon is pointed North. The angle of the barrel is 30º with respect to the horizontal ground. A 150 kg shell is placed in the cannon. Upon firing, the cannon moves backwards horizontally with a velocity of 3.0 m/s. Calculate the speed of the shell.
A. 12 m/s
✓B. 28 m/s
C. 48 m /s
D. 21 m/s

32. A physics 20 student that doesn't know much about chemistry added several chemicals into a flask. As the chemicals reacted, a volatile reaction took place. The 0.400 kg flask (ignore the mass of the chemicals) exploded into three pieces. One 0.20 kg piece flew off in an easterly direction at a speed of 10 m/s. Another piece (mass 0.100 kg) flew off in a norhternly direction with a speed of 15 m/s. Find the speed of the third piece.

A. 25 m/s 36.9º W of S
✓B. 25 m/s 36.9º S of W
C. 5 m/s west
D. 35 m/s 36.9º N of W

33.

Students place two balls on a floor. The ○ ball with a mass 3.00 kg is initially at rest and the ● ball with a mass of 5.00 kg is put into motion so that it will collide with the ○ ball. After the collision, both pucks are moving as shown. (In the diagram, each ● and each ○ appears 1.00 s apart.)



What was the distance traveled by the ● ball as indicated on the diagram?
(8 marks)

white ball velocity after

$\mathbf{v_{white} = \Delta d / \Delta t}$

$\mathbf{v_{white} = 1.50\ m / (3 \times 1.00\ s)}$

$\mathbf{v_{white} = 0.500\ m/s}$

dark ball velocity after

$\mathbf{v_{dark} = \Delta d / \Delta t}$

$\mathbf{v_{dark} = 2.50\ m / (5 \times 1.00\ s)}$

$\mathbf{v_{dark} = 0.500\ m/s}$

$\mathbf{\cos ø = p_{x\ white} / mv}$

$\mathbf{p_{x\ white} = \cos 25^o \times 3.00\ kg \times 0.500\ m/s}$

$\mathbf{p_{x\ white} = 1.35\ Ns}$

$\mathbf{\cos ø = p_{x\ dark} / mv}$

$\mathbf{p_{x\ dark} = \cos 15^o \times 5.00\ kg \times 0.500\ m/s}$

$\mathbf{p_{x\ white} = 2.41\ Ns}$

$\mathbf{P_{x\ original} = p_{x\ after}}$

$\mathbf{P_{x\ dark\ before} = p_{x\ white\ after} + P_{x\ dark\ after}}$

$\mathbf{v_{x\ dark\ before} = (1.35\ Ns + 2.41\ Ns) / 5.00\ kg}$

$\mathbf{v_{x\ dark\ before} = 0.75\ m/s}$

dark ball velocity before

$\mathbf{v_{dark} = \Delta d / \Delta t}$

$\mathbf{\Delta d = v\Delta t}$

$\mathbf{\Delta d = 0.75\ m/s \times 4.00\ s}$

$\mathbf{\Delta d = 3.0\ m}$

34. During an elastic collision, which of the following is conserved?
A. neither momentum or kinetic energy
B. momentum
C. kinetic energy
✓D. both momentum and kinetic energy

35. What are the three collisions that happen in a car accident?
A. There is only one collision per accident
B. car hits car; cars continue and hit another car; all three cars hit something else
✓C. car hits something; person hits the inside of car; internal organs hit the skeleton.
D. car hits something; person hits other car owner; car owners hit lawyer

36. Herman was standing at the back of a bus doing 100 km/h when it hit the side of a mountain. If the bus stop in a fraction of a second, what happened to Herman?
A. He hit the floor of the bus.
B. He was Ok because he never studied Newton's laws.
✓C. He hit the front of the bus at 100km/h a fraction of a second after the bus hit the mountain
D. He escaped with less injuries than others.

37. If momentum is conserved, what happens when Herman increases his velocity on his bike?
A. Energy is conserved.
B. Momentum of his bike is unchanged.
✓C. The momentum of the earth is changed equally in the opposite direction.
D. Energy is lost to the universe.