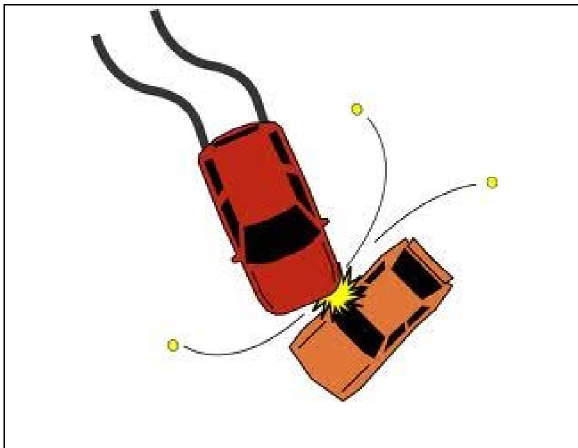
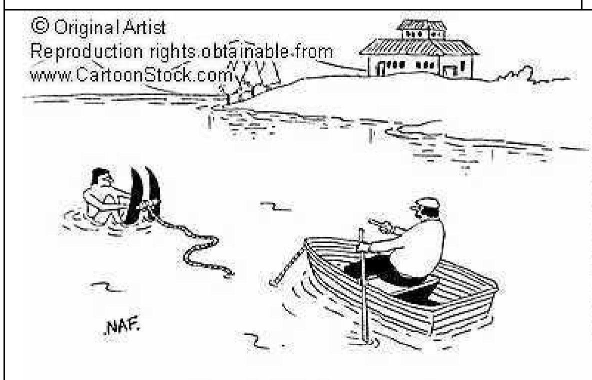
Physics Traditional 1314 Williams

Impulse & Momentum

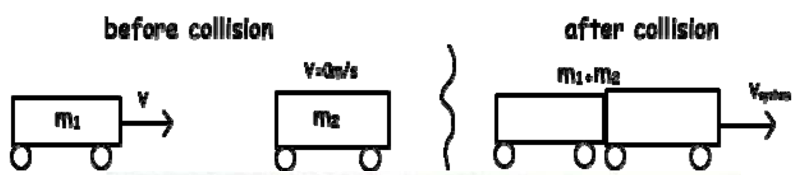
Chapter 6

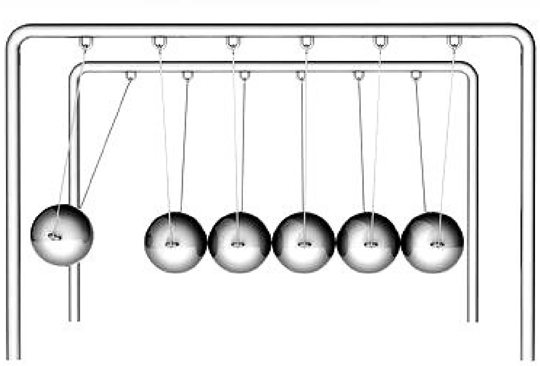


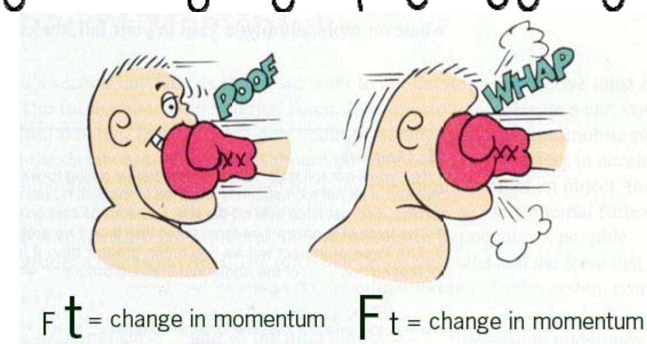


"Be patient, a few more strokes and I'll soon have the momentum going."

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







Top 10 "Momentous Ideas":

1. Understand the concept of momentum in terms of collisions, explosions, and in applied connections such as in pool, ice skating, karate, air bags, car motion, etc.

2. Use the equation for momentum to solve collision problems: momentum = mass * velocity

   or $p = mv$

3. Know that the total momentum of a system is always conserved (constant) So that in a collision one object's gain in momentum= other's loss in momentum

4. Recognize elastic collisions as bouncy frictionless interactions where kinetic energy is 100% transferred and the total kinetic energy is constant

5. Recognize inelastic collisions as sticky, hot, or destructive collisions where some Kinetic energy is converted to internal energy and kinetic energy is not constant.

6. Prove a collision is inelastic by showing the total kinetic energy is not constant

   Inelastic: $\Delta E_{k1} \neq \Delta E_{k2}$

7. Define impulse (I) as the momentum change, and impulse (F) as the force

8. Appreciate impulse equations are just Newton's laws reorganized:

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

   Or… $m\Delta v = F*\Delta t$ = "impulse or change in momentum"

9. Solve impulse problems involving the collision impulse force and contact time

   a. given a F vs t graph: Impulse= $m\Delta v$ = area under graph

   b. given force and time: Impulse= $m\Delta v$= $F*t$

10. Solve 2-d momentum problems (as in pool ball collisions) using vectors:

Concept Development Practice Page 7-1

1. A moving car has momentum. If it moves twice as fast, its momentum is __________ as much.

2. Two cars, one twice as heavy as the other, move down a hill at the same speed. Compared to the lighter car, the momentum of the heavier car is _________ as much.

3. The recoil momentum of a gun is (more than/ less than/ the same as) the momentum of the bullet it fires.

4. If a man firmly holds a gun when fired, then the momentum of the bullet is equal to the recoil momentum of the (gun alone/ gun and man together/ man alone).

5. Suppose you are cruising in a convertible when a kamikazi bug splatters itself into a gooey mess onto the windshield.
    a. Compared to the force that acts on the bug, how much force acts on the convertible? (more /the same/ less)

    b. The time of impact is the same for both the bug and the convertible. Compared to the impulse on the bug, this means the impulse on the convertible is (more /the same/ less).

    c. Although the momentum of the convertible is very large compared to the momentum of the bug, the change in momentum of the convertible, compared to the change in momentum of the bug is (more /the same / less).

    d. Which undergoes the greater acceleration? (convertible /bug / both the same)

    e. Which therefore suffers the greater damage? (convertible /bug /both the same)

6. Granny whizzes around the roller rink and is suddenly confronted with Ambrose at rest directly in her path. Rather than knock him over, she picks him up and continues in motion without braking. Consider both Granny and Ambrose as two parts of one system. Since no outside forces act on the system, the momentum of the system before the collision equals the momentum of the system after the collision.
a) Complete the table below.

Before Collision	
Granny's Mass	80.kg
Granny's Speed	3.0 m/s
Granny's Momentum	
Ambrose's Mass	40.kg
Ambrose's Speed	0 m/s
Ambrose's Momentum	
Total Momentum	

b) After the collision, does Granny's speed increase or decrease? ________________

c) After the collision, does Ambrose's speed increase or decrease? ______________

d) After the collision, what is the total mass of Granny and Ambrose? _______

e) After the collision, what is the total momentum of Granny and Ambrose? _______

f) Use the conservation of momentum law to find the speed of Granny and Ambrose together after the collision. Show formulas, substitutions, and units.
New speed = ____________

7. It's Homecoming, and the Devils are playing against LT and are determined to win. Unfortunately, with the Devils in the lead by only three points, LT has the ball and is close to scoring. It's fourth quarter with only seconds to go, and the Devils have called a time out. They gather around their coach for a quick physics lesson in momentum.

"All right, Devils, we've kept them on the run for most of the game, but now it's time to show 'em who's boss. Our scouts got some good data for us this time. We know the top speeds and masses of their four best ball carriers. We'd planned on matching them with these four defenders. Everyone grab your calculator so we can decide if this is the best plan."

Momentum Ideas

1. Momentum is ALWAYS conserved. If it looks like it isn't, it means you aren't considering all objects involved in the collision.
2. If kinetic energy is also conserved, the collision is elastic. This will occur when the object bounces off.
3. If kinetic energy is not conserved, some energy went into other forms. Energy was conserved, just not kinetic energy. This could be either a bouncing collision or a sticking collision.
4. When two object collide, their impulses are the same. This is because $I=F\Delta t$ and F=same (action/reaction) and they are in contact with each other for the same time.
5. There are two main types of impulse situations:
   a. When no matter what, the object ends up stopped. Impulse is the same, so all you can do is alter time or force. By lengthening the time, you reduce the force on the object. An example is landing straight-legged vs bending your knees when you land.
   b. When it is open-ended. The harder the force and the longer the time (preferably both), the greater the impulse and thus the greater the final momentum of the object. An example is hitting a baseball with a bat. The longer and harder you hit, the farther the ball will go because it gets more momentum than when you hit is softer or for less total time.
6. If the problem mentions force, you must use impulse.
7. If the problem mentions time, you must use impulse.
8. Impulse is the change in momentum.
9. If you are only looking at one object in the collision, the object's momentum will increase or decrease if there is an impulse. That means a force acting over time will alter its momentum.
10. The more momentum something has, the harder it is to stop.
11. An object which bounces has a greater impulse than one which just stops. The greater injury will occur with something which bounces because not only does the falling object lose all its momentum, it gains momentum in the opposite direction. It's like getting hit twice.
12. If the objects that collide and stick are not moving along the same line, multiply mv to find their momenta and then use a protractor and rules to add the vectors. Don't forget to get angle and amount!
13. If the two colliding objects are not moving along the same line and they rebound, break momenta into x and y parts and then treat them like separate problems. When you are done, use a right triangle to find the total final momentum of each object.
14. TNEOM still apply. If you have a friction problem, you'll need $f=\mu N$. If you have acceleration, try $F=ma$

Review for Momentum

1. How can two objects have the same momentum?
2. How is impulse related to change in momentum?
3. What is the momentum of a 80 kg student walking at 2.0 m/s?
4. What happens to momentum if speed is doubled?
5. What should you do to maximize the momentum of an object?
6. How do momentum and kinetic energy differ?
7. What are the units for momentum?
8. How can an object have a negative momentum?
9. What happens to the momentum of a coaster car if an impulse is applied?
10. Compare and contrast impulse with work
11. What is the momentum reason for using follow through in sports?
12. What is the function of a seatbelt?
13. Why is a bouncing collision more painful than a sticky collision?
14. How do air bags save lives? (use momentum, impulse terms)
15. What happens to the change in momentum if the contact time is doubled?
16. How are inelastic collisions different from elastic collisions?
17. When is the total momentum of a collision not constant?

18. What is the total momentum of two carts, each 0.5 kg, if one cart is moving at 4 m/s to the right and the other is moving at 10 m/s to the left?

19. What happens to the motion of air track carts when they collide and stick together?

20. If a heavier object collides with a lighter object, which object has the greatest change in momentum? How about the greatest change in speed?

21. What impulse is needed to stop a 90 kg football player running at 6.0 m/s?

22. A 20 kg red go-cart moving at 3 m/s hits a stationary blue 25 kg cart. The red cart bounces backwards at 2 m/s.
    a. What was the change in momentum of the red cart?
    b. What was the change in momentum of the blue cart?
    c. What is the velocity of the blue cart after the collision?

23. A 10 g dart is thrown at 20 m/s and sticks into a stationary 200 gram dart board.
    a. What was the change in momentum of the dart?
    b. What was the change in momentum of the dart board?
    c. What is the velocity of the combination dart plus dart board ?

24. What force is needed to accelerate a 4000 kg coaster from 0 to 5 m/s in 10 seconds?

25. Which has the most momentum - a fired bullet, person running, falling rain drop, parked car

121127SomeMomentumReviewQuestions

1. What is the difference between an elastic collision and a perfectly inelastic collision? With only initial and final velocity and mass information, how would you PROVE an elastic collision took place?
2. A baseball recoils from a baseball after being struck by a strong athlete with a 500 lb force (2225 N). If the ball was pitched at 35 m/s and left the bat traveling at 40 m/s in the opposite direction then what is the contact time with the bat?
3. You are an astronaut. Lucky you. While doing repairs you enjoyed the view of earth a bit too much and now you drifted away from your life line. All you have is a hammer in your hand. What would you do to save yourself?
4. A 1,000 kg car moving at +30 m/s strikes a 15,000 kg truck head on going at -20 m/s. If the contact time between the two is 0.200 seconds then what is the force (force is a vector!) is exerted on the car?
5. A 500 g hammer head hits brick while moving forward at 20 m/s. Assuming the contact time is the same in either case, does it matter if the hammer recoils or not? (explain)
6. You're going at 40 mph and your brakes fail. You're faced with steering toward a brick wall or a soft pile of hay. Either of these will stop you.
    a. Which option produces the smaller impulse?
    b. Which option probably results in a force too small to bend a steel bumper and why?
7. Thanksgiving is over and you have a job tossing turkeys to your assistant who happens to be on, of all things, a frictionless cart.
    a. What kind of collision takes place between your tossed turkey and the catcher?
    b. If you tossed the turkey forward (with a positive velocity), then is the impulse on the turkey positive, negative or zero as a result of being caught?
    c. Which is greater: The magnitude of the turkey's momentum prior to colliding or the momentum of the "turkey + catcher" after the catch?
    d. After the catch compared to before it, does KE overall go up, down, or remain a constant?
8. I like to play tennis. Most tennis players know that stringing a racquet kind of loose "increases power", but decreases control. Why do loose strings allow players to hit the ball harder?
9. A tiny car strikes a massive truck. Which vehicle receives a greater force upon impact?
    a. The car
    b. The truck
    c. Can't tell without knowing velocities
    d. Correct choice is none of the above
    e. Leave me alone, can't you see I'm trying to text!
10. You and your friend Sam both got frictionless carts as your Thanksgiving presents (What? Don't your parents love you enough to give you a Thanksgiving present?). Initially motionless, you stick your feet out of your cart and push Sam backwards. Comment on the following assumptions as to whether they are right or wrong regarding this situation:
    a. You pushed on Sam, so Sam moved and you didn't
    b. Momentum before pushing was the same as momentum after (zero)
    c. You exerted a greater force on Sam than Sam did on your
    d. Your speed will be greater than Sam's if you are more massive
    e. Your velocity will be the same as Sam's provided your masses are the same
11. Tony Hawk is a famous skateboarder who has a mass of about 75 kg. Today he is lazy and wants you to throw a 15 kg medicine ball at him. You do hoping it will drive him up the ramp but he only ascends 0.25 m. How fast did you throw the ball at Tony?
12. A punter kicks a ball straight up in the air to produce maximum hang time. Assuming the football goes up to a height of 20 m then using conservation of energy and impulse-momentum, how long is the ball in contact with his foot if he exerts a 2000 N force on the ball?
13. What is the frictional force to stop a 1200 kg car going 27 m/s over a distance of 30 m? (use impulse momentum to solve, not conservation of energy).

Unit 06 – Vocabulary and Equations – Impulse & Momentum

Vocabulary:

previous vocabulary
internal energy
elastic collision, perfectly inelastic collision
conservation of momentum
conservation of energy
deformation energy, internal energy

Symbols:

p, m, v,

Equations & constants:

You get these on test:

$v = \dfrac{\Delta x}{\Delta t}$ $a = \dfrac{\Delta v}{\Delta t}$ 1 mi. = 1609 m =5280 ft, 1 m/sec = 2.24 mph, 0.4536 kg = 1 lb

$\Delta x = v_0 \Delta t + \frac{1}{2} at^2$, $v_f^2 = v_i^2 + 2a \Delta x$

$v = v_0 + a \Delta t$ (v means v_f)

$v_x = v \cos\Theta$, $\Delta x = v_x t$, $v_i = v \sin \Theta$, $\Delta y = v_y t$

$F = ma$ $F_f = \mu F_n$ $p = mv$ $I = \Delta P = F\Delta t$

$W = Fd$ $P = W/t$ $PE = mgh = mg\Delta y$ $KE = \frac{1}{2} mv^2$

$W = \frac{1}{2} kx^2$ $F = kx$

1 hp = 746 W, 3,600,000 J = 1 kW-hr, 1 lb = 4.45 N

$m_{1i}v_{1i} + m_{2i}v_{2i} = m_{1f}v_{1f} + m_{2f}v_{2f}$

$\frac{1}{2}m_{1i} v_{1i}^2 + \frac{1}{2}m_{2i} v_{2i}^2 = \frac{1}{2}m_{1f} v_{1f}^2 + \frac{1}{2}m_{2f} v_{2f}^2$

Unit Objectives - Williams

1. I understand all the vocabulary & math of this unit and all demos, videos, equations, and class assignments.
2. I remember objectives & vocabulary from previous units.
3. I can compute momentum, know it's conserved in isolated systems and can contrast it with impulse and KE
4. Using momentum conservation, I analyze collision problems, finding final velocity & internal energy, etc.
5. A collision is not required for one object to affect the momentum of another, as in gravitational field forces
6. I can critically analyze collisions data and distinguish between elastic and perfectly inelastic collisions
7. I understand what impulse is and can apply it to find applied forces, contact times, etc.
8. I can use principles of impulse and momentum to understand the effects of longer collision times on forces
9. Using momentum, I can discuss the effect mass has on forces and energies exerted upon colliding objects of different masses
10. I know the units for momentum and know how these units differ from the units for energy
11. I know equal impulses don't mean equal consequences and can apply this in real situations, like landing on a cushion or a semi truck crashing into a car
12. I can analyze impulse and momentum equations from graphical information

DuPage ROE Objectives

301. I can identify momentum as the product of mass and velocity.
302. I can calculate the change in momentum (impulse) of one object which is acted on by a net external force.
303. I can analyze the momentum of a system of objects in one dimension.
304. I can distinguish between elastic and inelastic collisions
305. I can solve problems using conservation of momentum where the net external force is zero.
406. I can identify that energy is transferred between different forms
411. I can differentiate between conservation of momentum and conservation of energy.

<u>Physics Calendar - Impulse & Momentum: 2013-14(Williams) - Chapter 6 (9 days)</u>

Bold and underlined means put in journal notes (for any problems: Show your work!);

1	Tu:11/12/13	GOALS: Momentum introduction • Concepts: def., conservation, impulse/forces • Momentum demo with calculations (collisions) • Work time (Go Kart problems?)	• **<u>(06-01)</u>** Notes: Impulse/Momentum**:3,4,5,6,7,8, 9,10** • **<u>(06-02)</u>** p 199: 1-3; p 201: 1-4
2L	We:11/13/13	GOALS: Just enough circular motion for trip • Push someone in a square circle (direction for F) • What pushes a go kart (or your car) in a circle? • Few circular motion friction problems	• **<u>(06-03)</u>** Notes: Car's Stopping Distance & graphing**:1,12** • **<u>(06-04)</u>** p 203: 1-3
3	Th:11/14/13	GOALS: Go Kart physics skills, braking • Find braking force using Impulse momentum AND conservation of Energy/Motion equations….should they give you the same force?	• **<u>(06-05)</u>** p 204: 1-5
4	Fr:11/15/13	GOALS: Go Kart Field Trip • Go Kart Field Trip, same questions for those not going	• Be nice to someone!
5	Mo:11/18/13	GOALS: Any Go Kart Q's? Momentum lab • HW check: Were you nice to someone? • Take and questions on field trip • Any Holt Q's? • Impulse/Momentum lab & work time	• **<u>(06-06)</u>** p 211: 1a, 1c, 3 • p 214: 1,3,5; p 216: 1,3
6	Tu:11/19/13 Parent part	GOALS: Go over lab, clickers, work time/quiz • Clickers/parent intro • Lab Q's/go over • Group quiz or work time	• **<u>(06-07)</u>** p 214: 2, 4; p 216: 2
7	We:11/20/13	GOALS: Review/practice • Clix • Decide on tomorrow? (BBall review game? Group independent study?)Go over any Q's • Group quiz or work time	• **<u>(06-08)</u>** p 219: 1-4
8	Th:11/21/13	GOALS: • Class choice on review • Prepare for test tomorrow	• Study for test
9	Fr:11/22/13	• Impulse & Momentum Exam	• Have a great weekend!