Chapters 4: Let's finish *why* things move….a.k.a. more fun with Newton!

Outline of today's class (apart from quizzes):

Back to Newton's 3rd Law with examples
Momentum & its conservation
Review/summary/examples of basic mechanics (Newton's Laws and (only superficially) momentum conservation)

<u>Newton's 3rd Law</u>: "action = reaction"

Modern Physicist's view: Force = Interaction between 2 objects ("can't touch without being touched")

Demos: slap, push off wall…..jet cart!

The Law of Force Pairs[6]

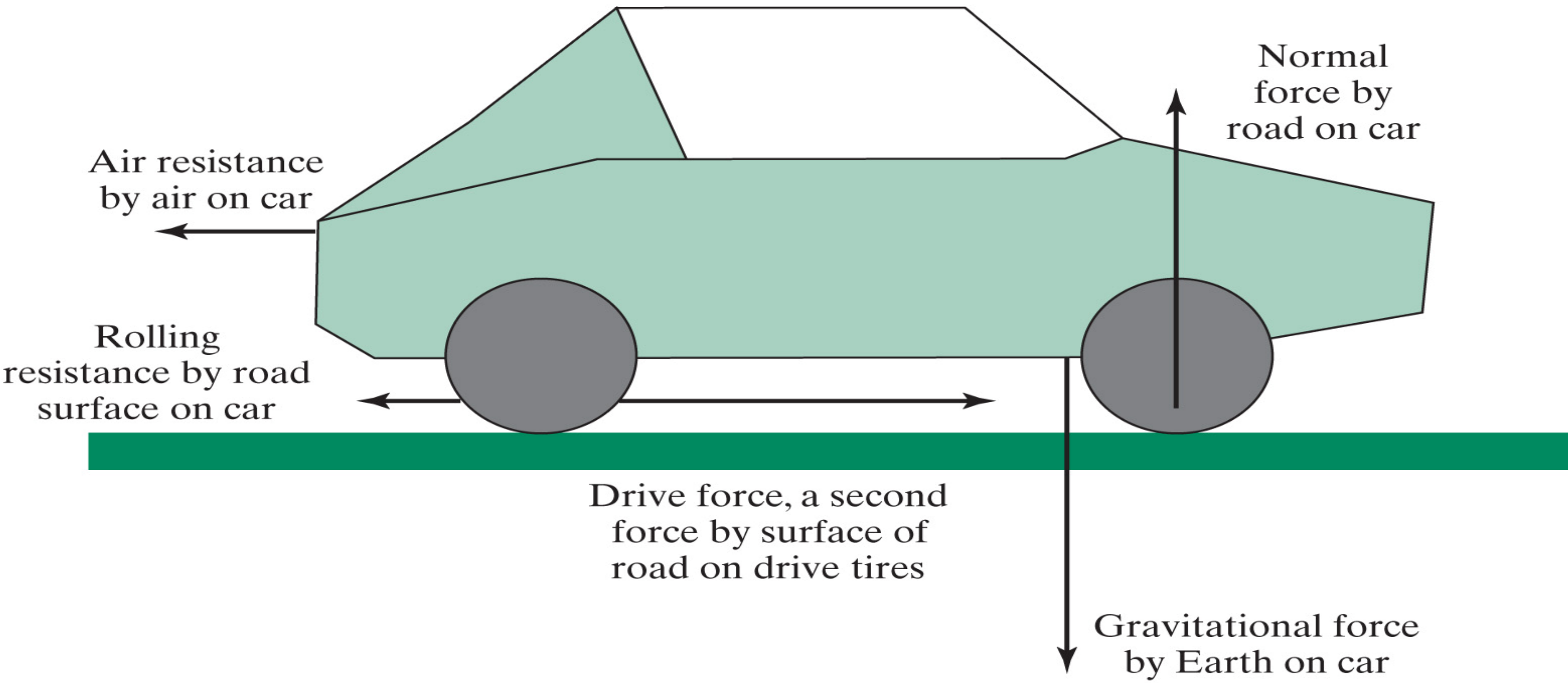
Every force is an interaction between two objects. Thus, forces must come in pairs: Whenever one body exerts a force on a second body, the second exerts a force on the first. Furthermore, the two forces are equal in strength but opposite in direction.

<u>Important</u>: 2 forces in a "*<u>force-pair</u>*" (in the context of Newton's 3rd Law) act on **<u>different</u>** objects!

The Automobile – what a great application of Newtonian principles. Example: car, straight level highway, steady 80 km/hr.

F_{net} = ? (magnitude & direction) F_{drive} = 0 ?

What if speeding up?   Slowing down?



Q: How to get off a frictionless icy pond? (Hint: you're wearing shoes and carrying a physics book.)

A: Kick off shoes and/or throw away that dreaded book!

→ Just discovered rocket propulsion! (Remember the jet cart)

Could an airplane operate outside earth's atmosphere?

What is the force pair for a falling object?

Newton & automobile accidents – problems 17 & 18:

10^3 kg runs into stationary 6×10^4 kg, with $F_{on\ truck} = 3\times10^4$ N

F_{oncar} = ? Direction? a_{car} vs. a_{truck} - directions, i.e. accelerating or decelerating?

$a_{car} = 30$ m/s^2 (~3"g"!) - decelerating (ouch!)

$a_{truck} = 0.5$ m/s^2 (small!) - accelerating

Quiz # 20:

A big truck and a small car collide head on, i.e. both are moving before the collision. Regarding the forces and accelerations:

(a) truck & car exert equally large forces on each other and their respective accelerations are also equally large

(b) forces are not equally large, but accelerations are

(c) larger force by truck on car, therefore a_{car} larger than a_{truck}

(d) equally large forces, and a_{car} smaller than a_{truck}

(e) equally large forces, and a_{car} larger than a_{truck}

C.E. 43 & 44: make sure you understand all forces involved

and whether members of a *force pair* or not.

C.E. 50: higher tire pressure --> harder tires --> less flexing and therefore less rolling friction.

C.E. 54: forward accelerating force out of NYC and backward decelerating (braking) force in Chicago.

Quiz # 21: A freely falling apple weighs 1 N. Earth's mass is 6×10^{24} kg. The force exerted *by the apple on Earth*

(a) is 1 N

(b) there is no such force

(c) is 6×10^{-24} N

(d) is 6×10^{24} N

Quiz # 22: A car ($W = 1.2 \times 10^4$ N) drives a steady 100 km/hr on a level, straight road. Its rolling resistance and air resistance are 500 N each. The strength of the drive force is

(a) 1.1×10^4 N (b) 1.2×10^4 N (c) 10^3 N (d) 1.2×10^3 N

Quiz # 23: An object dropped into a fluid tends to initially accelerate, and then drop at a constant terminal velocity. During the acceleration phase

(a) the object's weight is larger than the drag/friction force ("viscosity").

(b) the drag/friction force is larger than the weight.

(c) those two forces are equal.

(d) the relation between those forces is unclear because the mass of the object is not given.

→And what about at terminal velocity?

Quiz # 24: A car is coasting at constant velocity when its drive force drops from some value to 800 N, while its air resistance and its rolling resistance remain constant at 500 N *each*. What happens to the car's motion at that time?

(a) Nothing, i.e. it will continue to coast.

(b) It will accelerate.

(c) It will decelerate.

(d) Need the initial velocity to answer.

And what was the initial drive force?

"Momentum" = mass × velocity (a vector); $p = mv$

Why relevant?

Because of an extremely important *conservation law*:

If $F_{external}$ (on a "system", i.e. more than 1 object) = 0, then p_{total}(of system!) = const. → Newton's cradle!

Please make sure to go through "How do we know p is conserved?" on p. 85/86, and note the important assumption of *only internal forces*!

> **The Law of Conservation of Momentum**
>
> The total momentum of any system remains unchanged, regardless of interactions among the system's parts, so long as no part of the system is acted upon by forces external to that system.