Two ways to analyze forces

Newton's 2nd Law

Find the **NET** force **ON** an object

F = ma

Net force = mass x acceleration

Newton's 3rd Law

For every force, there is an equal and opposite force

~~Action/Reaction pairs~~

Force Pairs

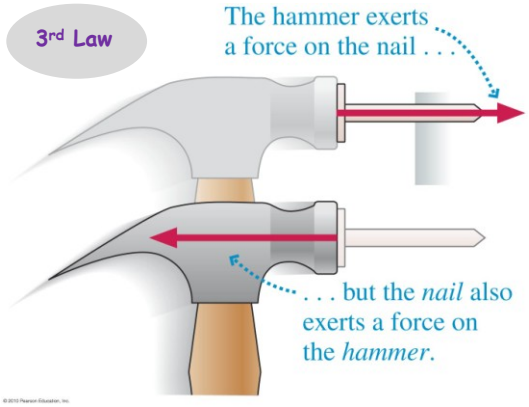
You push on a Wall

- don't fall through

3rd Law

- Wall pushes on you

3rd Law



Net Force

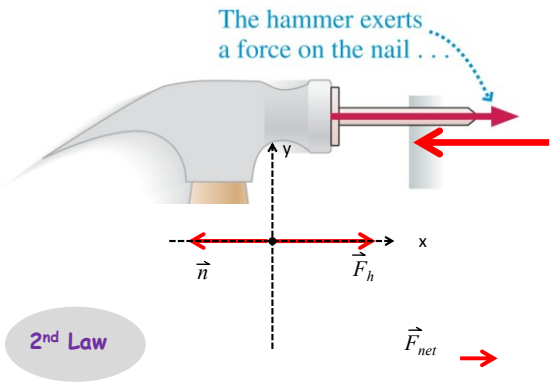
Consider the following forces:

1. Force of hammer on the Nail
2. Force of the nail on the Hammer
3. Force of wall on nail
4. Force of nail on the wall

2nd Law

Which of the above forces should be considered to determine the motion of the nail?

A. 1, 2, 3 and 4
B. 1 and 3
C. 1, 2 and 3
D. 2 and 4
E. 1 and 4



Net Force

Consider the following forces:

1. Force of hammer on the Nail
2. Force of the nail on the Hammer
3. Force of wall on nail
4. Force of nail on the wall

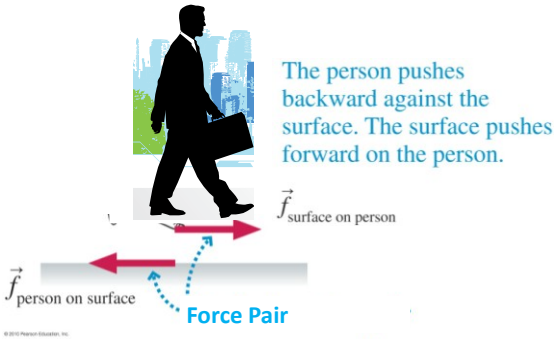
3rd Law

Which of the above forces are **force pairs**?

A. 1/3 and 2/4
B. 1/2 and 3/4
C. 1/3 only
D. None of them are pairs

Bullet

Walking



Slipping

What happens to your back foot if you slip?

A. It slides behind you
B. It slips out from under you (forward)
C. It slips sideways

Slipping

What happens to your front foot if you slip?

A. It slides behind you
B. It slips out from under you (forward)
C. It slips sideways

What happens without friction?

Watch the feet

What happens to the front foot?

What happens to the back foot?

What happens without friction?

What happened to the front foot?

What happened to the back foot?

Slipping

What happens to your back foot if you slip?

A. It slides behind you
B. It slips out from under you (forward)
C. It slips sideways

Slipping

What happens to your front foot if you slip?

A. It slides behind you
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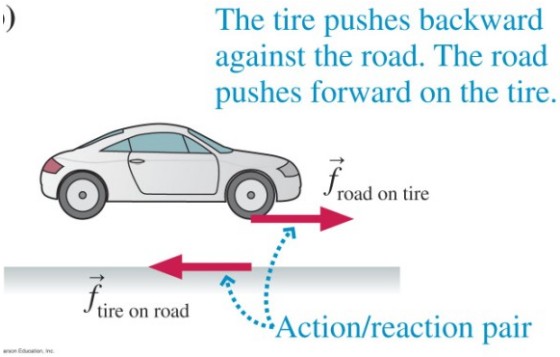
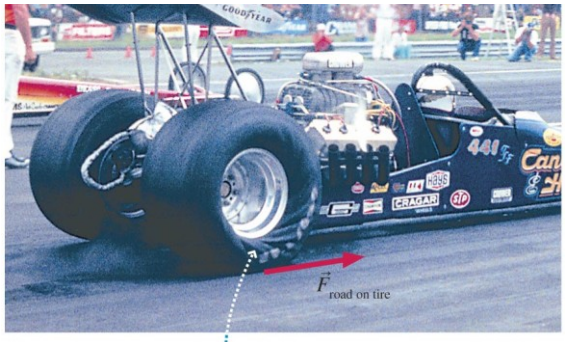
Propulsion





You can *see* that the force of the road on the tire points forward by the way it twists the rubber of the tire.

Static or Kinetic?

- **Kinetic friction** is when the two surfaces are sliding against each other.
- **Static friction** is when they are stuck together – no slipping.

Focus on the point of contact

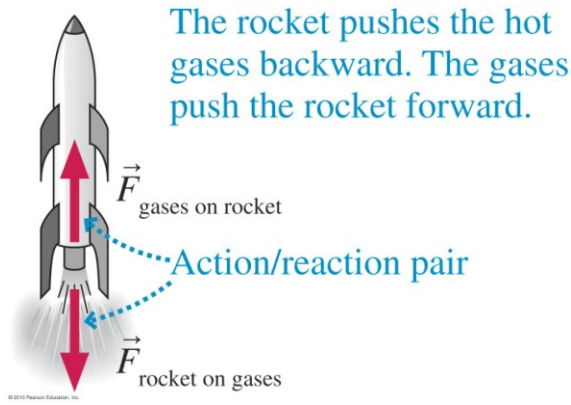
Slipping?

Yes – kinetic No - static

Static Friction

Are the points of contact slipping?

A. No
B. Yes
C. Depends on the situation



Gut Instinct?

A 2000 kg truck hits a 1000 kg car.

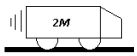
Suppose the **truck** slows down by **5 m/s** during the collision.

Does it sound reasonable to say the **car** speeds up by **10 m/s**?

A. Yes
B. No

Find **acceleration**

Let's say they stay in contact for 0.50 seconds

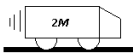


$a_{\text{truck}} = \Delta v/\Delta t$ = -5m/s / 0.50s = -10 m/s^2

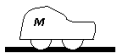
$a_{\text{car}} = \Delta v/\Delta t$ = 10m/s / 0.50s = 20 m/s^2

Find **force** felt by each

$$\vec{F} = m\vec{a}$$



F_{truck} = 2000kg * -10 m/s^2 = -20,000 N



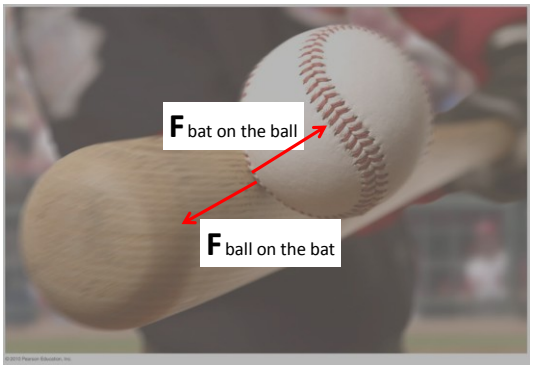
F_{car} = 1000kg * 20 m/s^2 = -20,000 N

Newton's 3rd Law

- This is why the book says it's **not** good to say
  "for every action there is an equal and opposite reaction"
- I'd say we just saw that:
  "for every force there's an equal and opposite force - force pair"
- And that the ***result*** (change in speed) of these ***equal forces*** depends on ***Mass***!!

Pairs of Forces

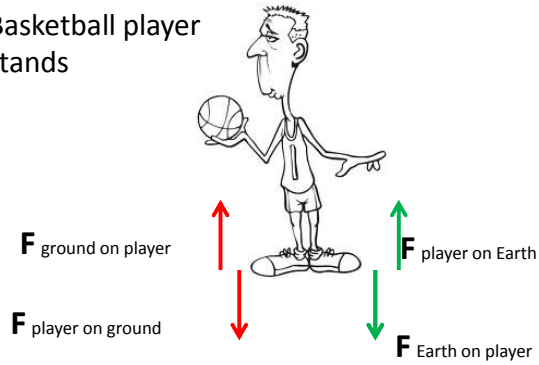
- Force of A on B and Force of B on A



Bat and Ball – only objects of interest

How do basketball players jump?

Basketball player stands



Free body diagrams

- Only forces ON the object of interest.
- NEVER force pairs because A on B / B on A.
  - Not on the same object.

Naming conventions

What is another correct name for "force of ground on player"?

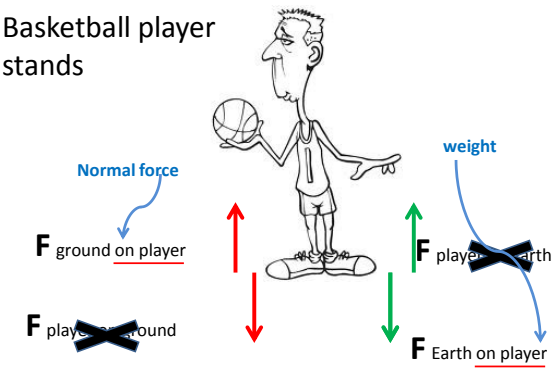
A. Friction
B. Weight
C. Normal
D. Tension

Naming conventions

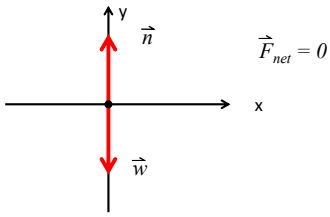
What is another correct name for "force of earth on player"?

A. Friction
B. Weight
C. Normal
D. Tension

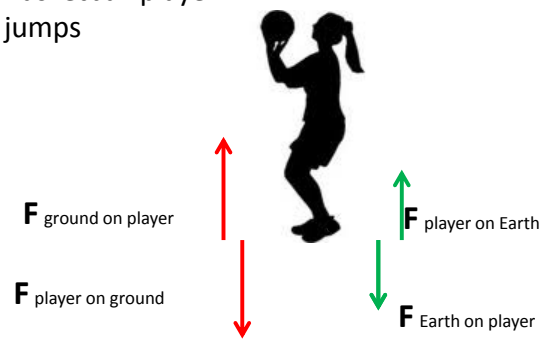
Basketball player stands



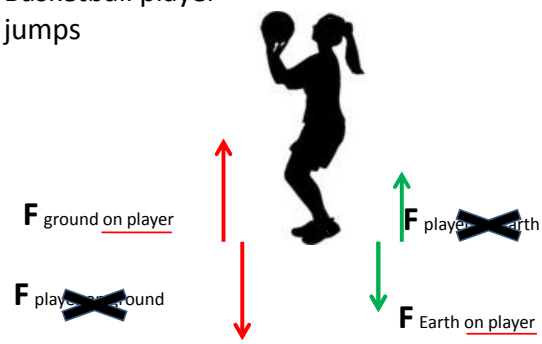
Free Body Diagram (FBD)
Player standing



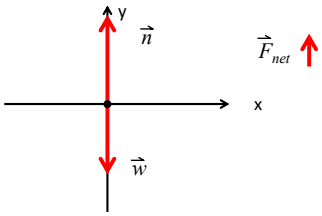
Basketball player jumps



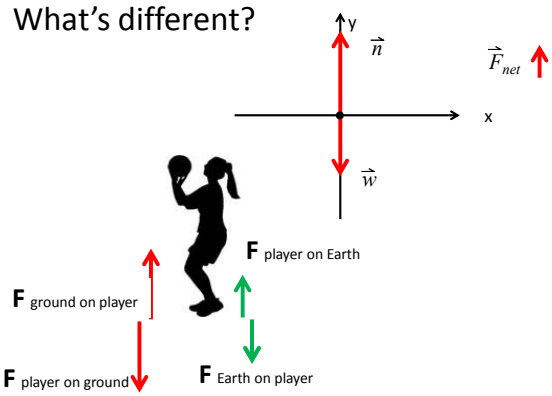
Basketball player jumps



Free Body Diagram (FBD)
Player jumping



What's different?



Newton's First Law

Consider an object with no force acting on it.

If it is at rest, it will remain at rest;

If it is moving, it will continue to move in a straight line at a constant speed.

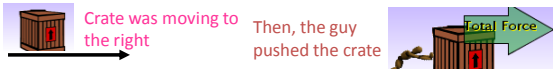
The natural state of an object – its behavior if free of external influences – is *uniform motion* with constant velocity!

At rest is $v = 0$

Newton's 2nd Law

$\vec{F} = m\vec{a}$

Net force = mass x acceleration



1. If the **total force (net Force)** acts in the same direction as the crate is sliding, the crate

A. slows down
B. speeds up
C. remains at same speed
D. slows down, changes direction and then speeds up going the other way
E. remains at same speed, but changes direction

Cabinet was moving to the left

Then, the guy pushed the cabinet

2. If the **total force (net Force)** acts in the opposite direction as the cabinet is sliding, the cabinet would

A. slows down
B. speeds up
C. remains at same speed
D. slows down, changes direction and then speeds up going the other way
E. remains at same speed, but change direction

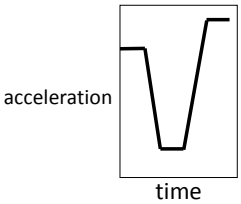
Refrigerator was moving to the right

Then, the guy pushed the refrigerator

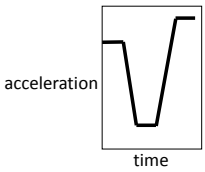
3. If there is zero **total force (net force)** acting on the refrigerator, the refrigerator would

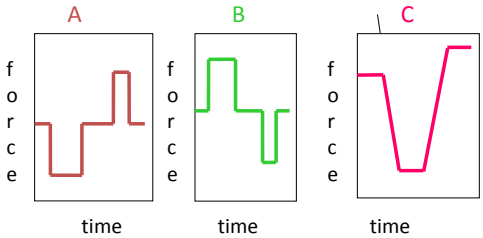
A. slow down
B. speed up
C. remain at same speed
D. slow down, change direction and then speed up going the other way
E. remain at same speed, but change direction

A car is traveling along a road. Its acceleration is recorded as a function of time.

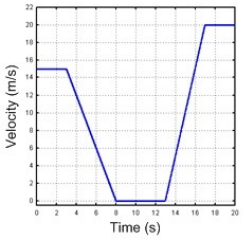


Which **Total force-time** graph would best match the scenario?

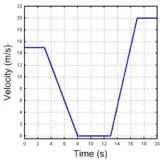


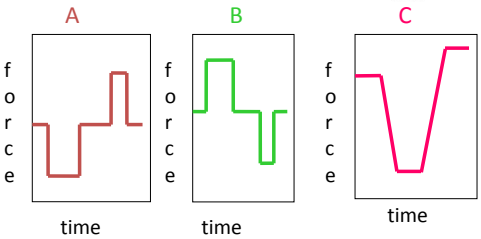


A car is traveling along a road. Its velocity is recorded as a function of time.



Which would be the **Total force-time** graph?





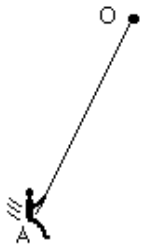
The figure below shows a boy swinging on a rope, starting at a point higher than A.

Consider the following distinct forces:

1. A downward force of gravity.
2. A force exerted by the rope pointing from A to O.
3. A force in the direction of the boy's motion.
4. A force pointing from O to A.

Which of the above forces is (are) acting on the boy when he is at position A?

(A) 1 only.
(B) 1 and 2.
(C) 1 and 3.
(D) 1, 2, and 3.
(E) 1, 3, and 4.



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