Notes 3.1 – Forces & Free-Body Diagrams

Name: Key ______________________ Date: ~~[illegible]~~ Oct 2nd ________ Hour: 3 ______

arning Goals:

- Distinguish between contact and non-contact forces (P3.1A)
- Identify basic forces (with direction) in everyday interactions (P3.1d)
- Create a free-body diagrams of everyday interactions (P3.2A)

I. FORCE – Definition:

A vector quantity (magnitude and direction) that attempts to change an object's state of motion (or causes an acceleration of any kind).

II. TYPES OF FORCES

A. Contact Forces: Require contact for forces to be felt.

1. Applied – (F_A) push, pull, shove, bump in any direction
2. Tension – (F_t) "Stretching" force in objects that are not "springy" (any direction)
3. Spring/Elastic – (F_s) stretching force in springy objects
4. Friction – (F_f) Force between 2 objects in contact in the direction opposite of motion
5. Air resistance – (F_{air}) The friction of air (direction is opposite motion)
6. Normal – (F_N) Support force applied by a surface, perpendicular to surface

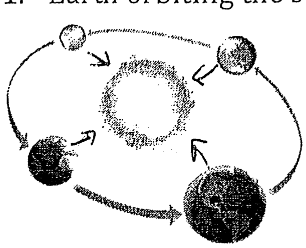
B. Non-contact Forces: Do not Require contact for forces to be felt.

1. Gravity/weight – (F_g) Force of attraction between two particles of matter due to their mass and the distance between them
2. Electromagnetic – (F_e or F_m) Force of attraction or repulsion between 2 particles of matter due to electric $ magnetic Fields.

III. IDENTIFYING FORCES

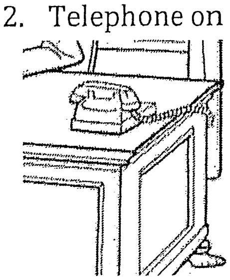
Identify all the forces acting on the objects. The number in parentheses tells you how many there are.

1. Earth orbiting the sun in space (1)



(F_g) - Gravity

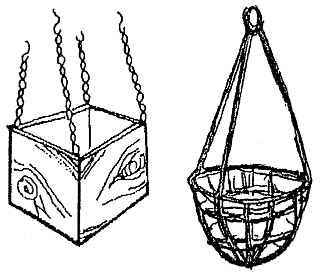
2. Telephone on desk (2)



(F_N) - Normal

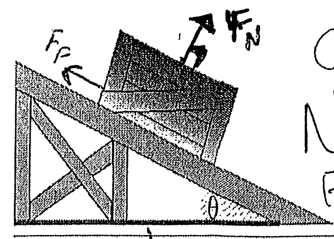
(F_g) - Gravity

3. Hanging plant (2)



gravity (F_g)
tension (F_t)

4. Sliding box (3)



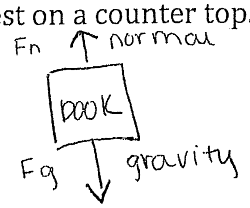
gravity (F_t)
Normal (F_n)
Friction (F_f)

F_G

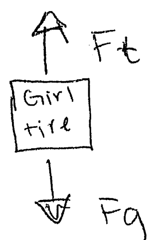
IV. DRAWING FREE BODY DIAGRAMS

When drawing free body diagrams, all objects are represented with a square with arrows pointed away from the square to represent any forces acting on the object. Draw a free body diagram of the bolded objects below.

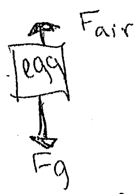
A. A **book** is at rest on a counter top.



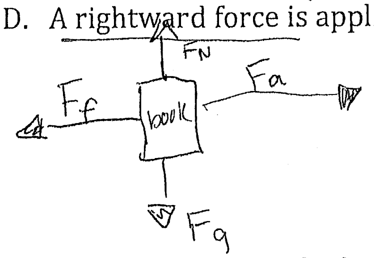
B. A girl is sitting motionless on a tire swing. Draw a diagram for the **girl & tire** as if they were one object.



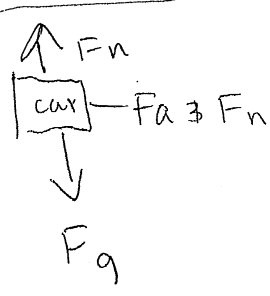
C. An **egg** is falling from a nest in a tree.



D. A rightward force is applied to a **book** sitting on a desk.



E. The brakes are applied to a leftward moving **car** and it skids to a stop.



Notes 3.2 – Newton's First Law

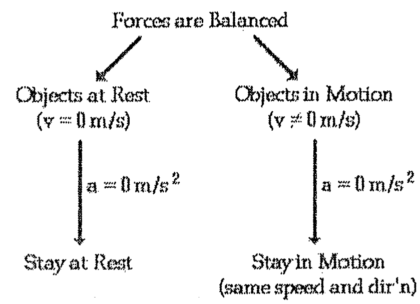
Name: Key Date: ________ Hour: ______

Learning Goals:

- State Newton's Laws of motion and identify examples of each
- Predict motion of an object that's being acted on by several forces (P3.4A)
- Identify forces acting on objects moving with constant velocity (P3.4B)

I. **Law of Inertia states:** An object at rest will stay at rest and an object in motion will stay in motion with the same speed and in the same direction unless acted upon by an Unbalanced force.

AKA: Objects tend to "Keep doing what they're doing".



II. **Examples:**

A. Bowl of water being carried around a lab station. At what point will the water spill?
Start, Stop, change direction

B. Videos:

- Sewing Ring & Marking:
- Tablecloth:
- Egg drop:

C. Additional Examples:

- Lids placed on to-go cups so they don't spill
- Seat belts are worn in cars to prevent you from going through the windshield
- If you abruptly hit a curb while riding a skateboard, you will fly forward because the motion of the skateboard was changed

III. **Inertia**

A. Definition:

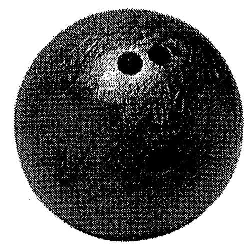
- Resistance an object has to a change in its state of motion.
- Resistance an object has to a Velocity.
- Resistance an object has to an acceleration.

B. History:

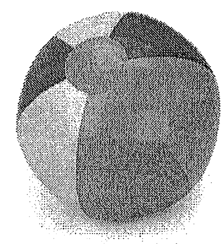
- Original Idea: All objects have a natural tendency to Stop.
- Galileo - First to propose friction causes objects to stop
- Newton - Forces don't keep objects moving, they change what the object is doing.

C. Inertia varies with mass.

- More mass → More of a tendency to resist change → harder to get moving or make stop

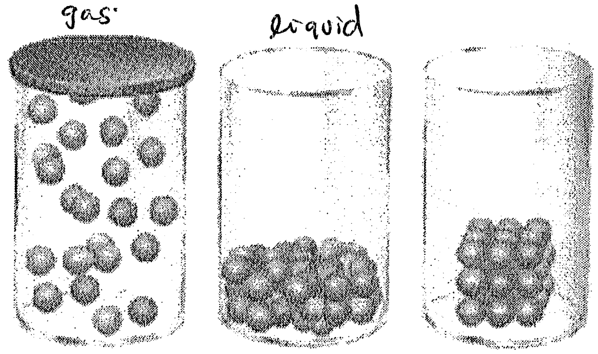


- Less mass → Less of a tendency to resist change → easier to get moving or make stop



D. Mass v. Volume v. Weight

- Mass – How much matter (particles) in an object
- Volume – How much Space an object occupies
- Weight – Equals the force of gravity on an object (dependent on the mass of the two objects).



* all same mass

different volumes

Notes 3.3 – Calculation with Net Force

Name: ____________________ Date: __________ Hour: ______

Learning Goal:

- Calculate net force (P3.2C)

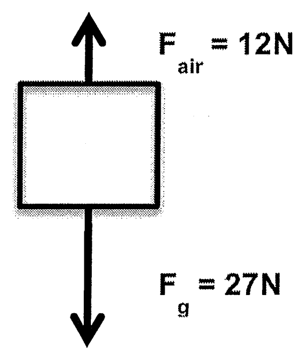
I. Force as a Unit of Measurement

- Unit: Newton (N)
- Net Force: ____________________
  (Forces acting in the x-direction are separate from those acting in the y-direction)

II. Calculating Net Force

- In each of these problems, all of the forces acting on an object are given. Use them to calculate the net force.
- Assume all forces down and left are negative.
- Total forces in each direction (x and y)
  1. $F_{net\text{-}x} = F_{x1} + F_{x2}$ + etc.
  2. $F_{net\text{-}y} = F_{y1} + F_{y2}$ + etc.
  Note: one net will always be zero

F_{NET} = −15 N



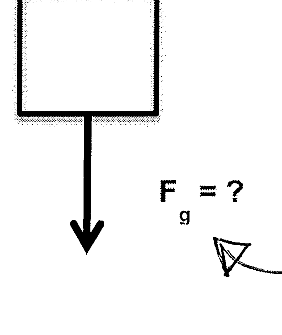
+12

−27

III. Calculating Unknown Forces

- In each of the problems, the net force is given. Use it to calculate any unknown forces.
- Assume all forces down and left are negative.
- Plug known values in to equations below & solve:
  1. $F_{net\text{-}x} = F_{x1} + F_{x2}$ + etc.
  2. $F_{net\text{-}y} = F_{y1} + F_{y2}$ + etc.
  Note: one net will always be zero

F_{NET} = 30N, down



$F_{net} = F_A + F_g$

$-30 = 7 + F_g$

[illegible]

$F_g = -37\,N$

3.5 Notes – Newton's Second Law

Name: Key Date: ______________ Hour: ________

Learning Goals:

- Calculate net force (P3.2C).
- Solve F=ma calculations (P3.4D).

Force = newtons (N)
mass = Kilograms (kg)
accel = meters / second^2 = (m/s^2)

I. Newton's Second Law States: The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object.

   A. As an equation: $a = F/m$

   B. Rearranged: F = ma

II. Practice Calculations:

   A. Determine the acceleration that results when a 12N net force is applied to a 3kg object.

$F = ma$

$12N = (3kg)\,a$

$a = \frac{12}{3} = 4\ m/s^2$

   B. A net force of 15N is exerted on an encyclopedia to cause it to acceleration at a rate of 5 m/s^2. Determine the mass of the cyclopedia.

$F = ma$

$15N = m(5m/s^2)$

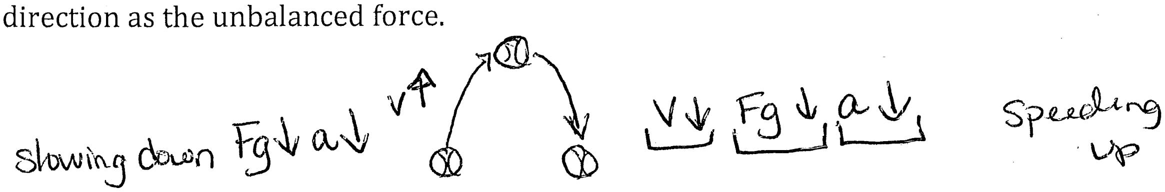
$m = \frac{15}{5} = 3\ kg$

III. Tough Pills to Swallow (Misconceptions)

   A. First Law: Once a contact force (push, throw, cannonball launch, etc.) is no longer in contact with an object, it cannot force it do anything. However, the object can still be moving.

   B. First Law: Objects that are moving do not require forces to stay moving.

   C. Second Law: An unbalanced force (or net force) causes an acceleration in the same direction as the unbalanced force.



IV. Helpful Things to Remember

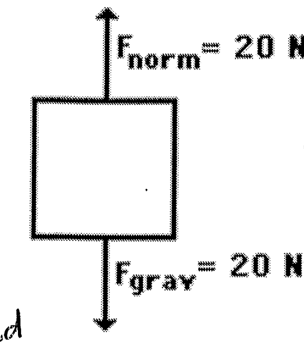
A. Free-body diagrams will NEVER tell you the direction an object is moving.

B. Balanced Forces = No accelration

C. Unbalanced Forces = acceleration

V. Practice with Misconceptions

A. The object represented by the free-body diagram:



$F_{net} = 0$

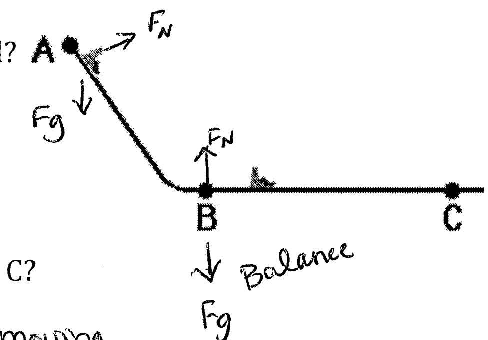
- CAN be at rest? ✓
- MUST be at rest? NO
- CAN be moving? ✓
- MUST be moving? NO
- CAN be accelerating? NO
- MUST be accelerating? NO

} because they are balanced

B. Use the image to the right & ignore friction and air resistance:

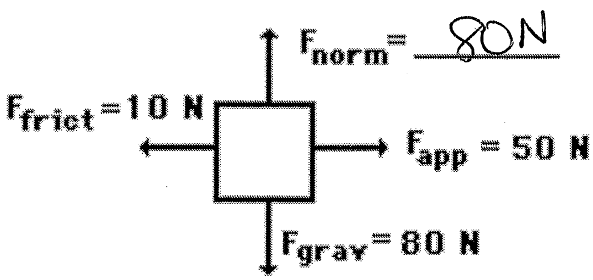
- At point A, are forces balanced or unbalanced?
- At point A, what causes the sled to go down the hill? gravity
- At point B, are forces balanced or unbalanced?
- At point B, what causes the sled to make it to point C?

Inertia - object moving stays moving



VI. Practice Calculations with Free-Body Diagrams:

A. An applied force of 50N is used to accelerate a 10kg object to the right across a frictional surface. The object encounters 10N of friction. Use the diagram to determine the normal force, net force, mass and acceleration of the object. (Neglect air resistance).



m = 10Kg

a = ? 4m/s²

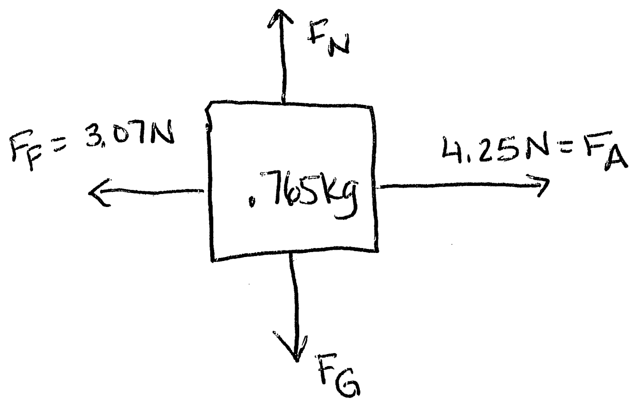
F_{net} = 40N right

$F_{net} = ma$

$40\,N = (10kg)(a)$

$a = \frac{40}{10} = 4\ m/s^2$

B. Edward applies a 4.25N rightward force to a 0.765kg book to accelerate it across a tabletop. The force of friction is 3.07N. Determine the acceleration of the book.



$4.25 - 3.07 = 1.18$

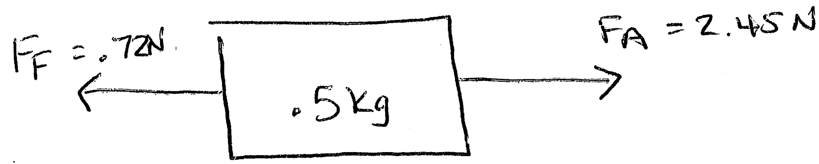
$F_{Net} = 1.18\text{ N left}$

$F_{Net} = ma$

$1.18\text{N} = (.765\text{kg})(a)$

$\frac{1.18}{.765} = a = \boxed{1.54\text{ m/s}^2}$

C. In a physics lab, Kate and Rob use a hanging mass and pulley system to exert a 2.45N rightward force on a 0.5kg cart to accelerate it across a low-friction track. If the total resistance force to the motion of the cart is 0.72N, then what is the cart's acceleration?



$F_{Net} = 2.45\text{N} - .72\text{N} = 1.73\text{N}$, right

$F_{net} = ma$

$1.73\text{N} = (.5\text{kg})(a)$

$\frac{1.73}{.5} = a$

$a = 3.46\text{ m/s}^2$, right

3.6 Notes: Weight, Free-Fall & Air Resistance

Name: ______________________ Date: ____________ Hour: ________

Learning Goals:

I. Weight

A. Definition: Force of gravity on an object

B. Equation: F_g (weight) $= mg$ or $W = mg$

- "g" is the acceleration due to gravity
- g = $9.8\ m/s^2$ for all objects on Earth ($\approx 10 m/s^2$)

C. Example Calculation: An object has a mass of 35kg. What is its weight in Newton's?

$W = mg$

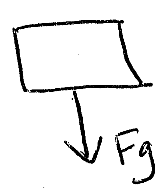
$W = 35kg \cdot 9.8 m/s^2$

$W = 343\ N$

II. Free-Fall

A. Definition: State of motion where only gravity is acting on the object.

B. Free-Body Diagram:



C. Practice Situations: Are the following objects in free-fall?

- A person parachuting to Earth NO
- A person skydiving (before shoot opens) NO
- A book falling off a shelf (neglect air res.) YES
- After being thrown, a ball traveling up toward its peak (neglect air res.) YES

D. Without air resistance, objects fall at the same rate & hit the ground at the same time (if dropped from same height)

- If "g" or acceleration due to gravity is the same for all objects, then all objects go from zero to faster at the same rate, get to the same final velocity in the same amount of time and cover the same distance

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

ratio is the same.

- Force of gravity is different because their MASS is different

E. Mythbusters Clip: http://www.youtube.com/watch?v=7eTw35ZD1Ig

III. Air Resistance

A. Definition: Frictional Force created by particles as objects pass thru a gas.

B. What affects air resistance?

- Density of Air (how many particles in the gas)

  High Density → More Air resistance

- Surface Area / cross sectional area of object

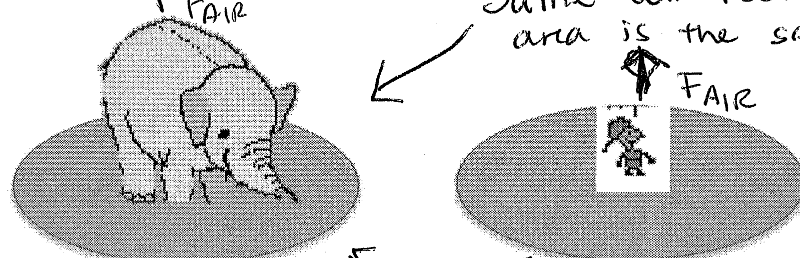
  Greater Area → more air resistance

- Speed of the object (think hand out the window of car)

  Faster → more air resistance

Eventually, air resistance = gravity, stop accelerating, hit max speed or terminal Velocity

C. With air resistance, heavier objects fall faster because air resistance is the same but force of gravity (weight) is not



D. With air resistance, objects do not fall at a rate of 9.8 m/s². It must be calculated using $F_{net} = ma$

3.7 Notes: Newton's Third Law

Name: ______________________________ Date: ______________ Hour: ________

Learning Goals:

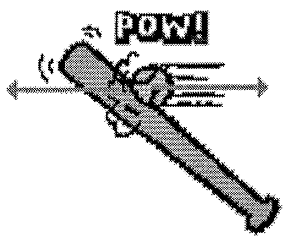
I. Newton's 3rd Law States: For every action force, there is an equal and opposite reaction force.

A. Note: Action FORCE & reaction FORCE (not events)

B. Action-reaction forces come in pairs & act on different objects

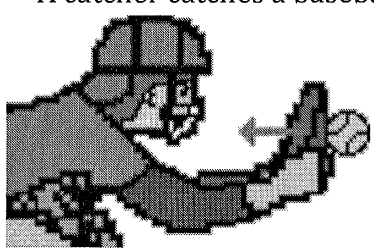
II. Examples – Name the action and reaction forces in each:

A. A baseball player swings his bat, hits the incoming baseball, and sends it soring over the left field wall for a homerun



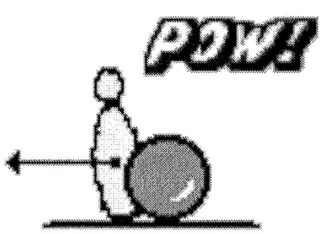
Bat hits ball
Ball hits bat

B. A catcher catches a baseball in his glove



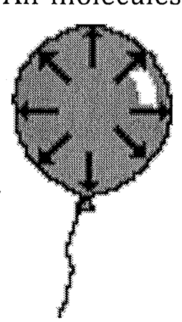
Ball hits glove
Glove hits ball

C. A bowling ball rolls down the lane and hits the last pin standing, causing it to fall



Ball hits pin
Pin hits ball

D. Air molecules fill a balloon



Air pushes on balloon
Balloon pushes on air