



Unit 1: Kinematics and Dynamics

Lesson 1.5: Free body diagram and Newton's Law of motion (Chapter 2.1 & 2.2)

Inertia: the property of matter that causes an object to resist any changes in motion. Objects have more mass have more inertia.

Then Newton developed his first law of motion after Galileo introduced his concepts of inertia.

**If you are interested in Galileo's inertia experiment, please go to:

<http://zonalandeducation.com/mstm/physics/mechanics/forces/galileo/galileoInertia.html>

Newton's first Law: If the external net force on an object is zero, the object will remain at rest or continue to move at a constant velocity.

Newton's second law: If the net external force on an object is not zero, the object will accelerate in the direction of the net force. The magnitude of the acceleration is directly proportional to the magnitude of the net force and inversely proportional to the object's mass.

$$\vec{a} = \frac{\Sigma \vec{F}}{m} \text{ or } \Sigma \vec{F} = m\vec{a}$$

*** Gizmos – Fan Cart Physics

<https://www.explorelarning.com/index.cfm?method=cResource.dspView&ResourceID=403&ClassID=2499654>

Newton's Third Law: For every action force, there exists a simultaneous reaction force that is equal in magnitude but opposite in direction. (action-reaction force)



Example 1: Use Newton's First Law and Action-Reaction force to analyze real world application

Older cars did not have headrests, but all new cars do. How do headrests help prevent injuries during a rear-end collision? Use Newton's first law to explain your answer.

Solution

Consider the forces acting on a person's body during a collision. During a rear-end collision, the car will suddenly accelerate forward and so will your body because the seat exerts a force directed forward on your torso. In a vintage car with no headrest

(Figure 6(a)), there is no force applied to the head. According to Newton's first law, your head will continue to remain at rest. Your head will initially appear to snap backwards relative to your body as your body accelerates forward, possibly resulting in a neck injury known as whiplash. The headrest in a modern car helps push the head forward with the rest of the body (Figure 6(b)). This helps to prevent whiplash since your neck does not bend backwards as far during a rear-end collision.

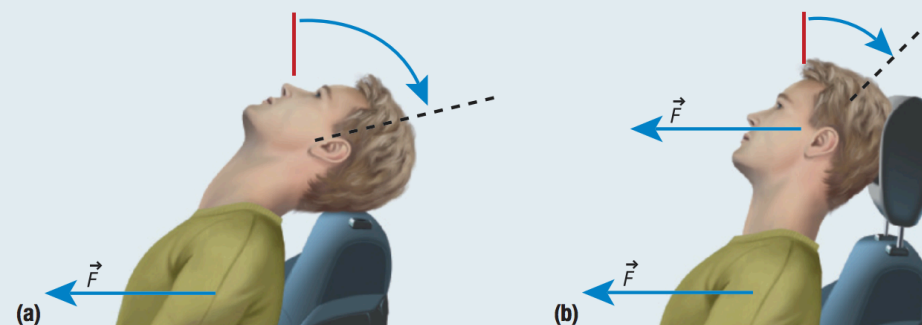
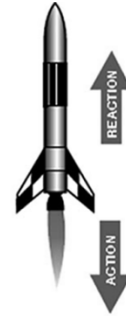
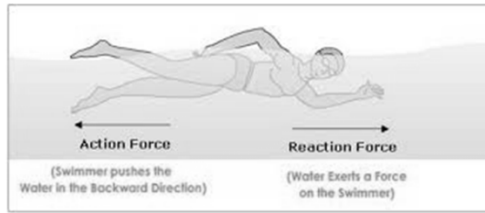


Figure 6 (a) No headrest (b) Headrest present

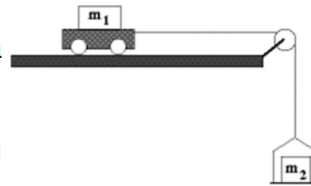


Example 2: Use action-reaction force to analyze real world application



Example 3: Tension force and acceleration problem

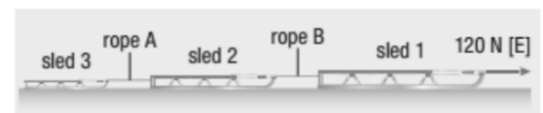
In an investigation a student placed a 0.85 kg cart on a table. They tie one end of a light string (assume 0kg) to the front of a cart, passes it through a pulley and then onto a 0.50 kg hanging mass. Assume there is no friction.



- Determine the magnitude of the acceleration of the cart and the hanging object.
- Determine the magnitude of the tension.

Practice 1: Tension force and acceleration problem

Three sleds are tied together and pulled east across an icy surface with an applied force of 120 N [E]. The mass of sled 1 is 11.0 kg, the mass of sled 2 is 10.0 kg and the mass of sled 3 is 6 kg. You can assume the ice is frictionless.



- Determine the acceleration of the sleds
- Determine the magnitude of the tension in rope A
- Determine the magnitude of the tension in rope B



Practice 2: Tension force and acceleration problem

Three dynamics carts have force sensors placed on top of them. Each force sensor is tied to a string that connects all three carts together (**Figure 10**). You use a sixth force sensor to pull the three dynamics carts forward. The reading on force sensor 2 is 3.3 N. Assume that the force sensors are light and that there is negligible friction acting on the carts. **T/I**

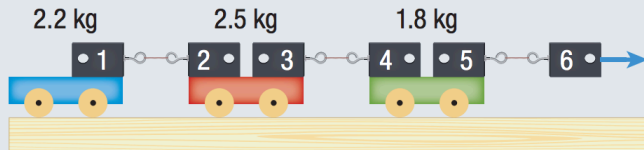


Figure 10

- What is the acceleration of all the carts?
- What is the reading on each force sensor?
- What force are you applying to force sensor 6?

Practice 3: Pulley Problem

(I will draw diagram on board!!!)

Tarzan (95kg) and Jane (65kg) are holding onto a rope one either side of a frictionless pulley.

- Calculate the acceleration of Tarzan & Jane
- Calculate the tension in the rope.



Practice 4: Apparent Weight – Person on scale in Elevator

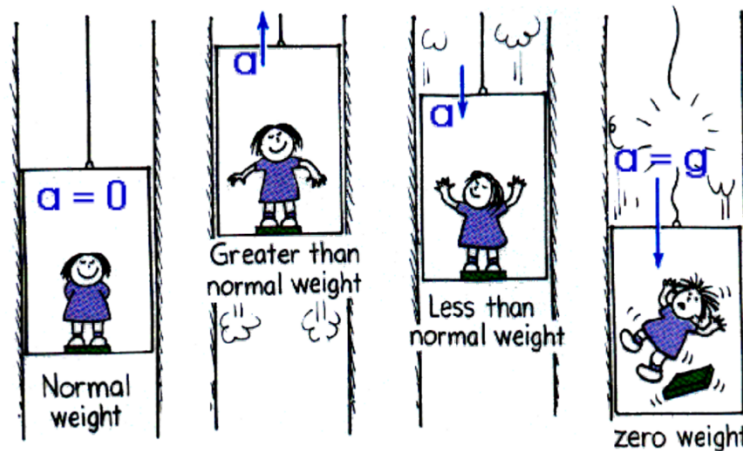
A person with mass, m , who is located at or near the surface of the Earth will always have some weight, $W = mg$. When a person stands on a scale, the reading (the number of pounds or newtons) on the scale is actually the Normal force that the scale exerts back towards the person to support the person's weight. (Note that the person and the scale are stationary relative to each other, in other words they are always in contact with each other, so they always have equal and opposite action and reaction forces acting between them.)

Things get complicated, though, when the scale and the person experience acceleration. This will change the contact force (the normal force) between the person and the scale.

Your task is to compare the relationship between apparent weight (normal force) and actual weight.

Just fill in $>$, $=$, or $<$ and briefly explain your choice.

Case 1: No acceleration of elevator Apparent Weight ____ Actual Weight	Case 2: Accelerating upward Apparent Weight ____ Actual Weight	Case 3: Accelerating downward Apparent Weight ____ Actual Weight
Case 4: Decelerating upward Apparent Weight _____ Actual Weight	Case 5: Decelerating downward Apparent Weight _____ Actual Weight	





Example 3: Kinematics & Newton's Laws

Starting from rest a 56.0 kg curler pushes out of the hack with a force of 145.0 N [forwards] and moves 5.50 m. She then moves at a constant velocity for 5.5 s before slowing down by dragging her foot. When she drags her foot she causes a net force of 42.0 N [backward] to slow her before she stops.



How far does she slide?

Practice 5: The vertical jump

An exceptional standing jump would raise a person 0.80 m off the ground. To do this, a 61 kg person crouches 0.20 m and pushes off from the ground, exerting a force on it. By Newton's third law, the ground pushes back with an equal and opposite force, which accelerates the person off the ground.

- What is the jumper's speed just as he leaves the ground?
- What force must he exert on the ground to perform the 0.80 m jump?

