Forces and Motion

Holt Book Chapter 4

Forces: A Video Introduction

- Misconceptions about Falling Bodies
  - http://www.youtube.com/watch?v=_mCC-68LyZM

- What is the Magnus Force? (advanced)
  - http://www.youtube.com/watch?v=23f1jvGUWJs

Holt book-- Ch4 sec4

COMMON FORCES

The Four Known Forces in the Universe

1. Strong Nuclear Force
   - The attractive force between all nucleons that holds the nucleus of an atom together (the force opposing radioactive decay)
     - Only acts over very short distances
     - The strongest of the four forces
2. Electromagnetic Force
   - The interactions of electrical and magnetic particles and the forces that result from their interaction
     - The force that repels atoms from one another
3. Weak Nuclear Force
   - Somehow related to the cause/nature of radioactive decay
     - (Mr. Rice needs to learn more about this one)
4. Gravitational Force
   - All matter is attracted to all other matter in the universe
     - (including dark matter???)
     - The smallest of all of the fundamental forces, and least understood

Common Forces

- A force is anything that pushes or pulls on an object (some texts will say only a push, and let a pull be a negative push)
  - **Applied force**: A literal push or pull
  - **Gravity**: The attraction of objects with mass
  - **Normal force**: Force applied by a surface opposing gravity
    - "normal" refers to the normal of a surface (from mathematics)
  - **Tensional force**: Force applied by a rope/string
  - **Frictional forces**: Forces that oppose motion
    - **Static friction**: Friction between two surfaces not in relative motion (the two are not moving compared to one another)
    - **Kinetic friction**: Friction between two surfaces in relative motion
    - **Rolling friction**: Friction between wheels and a surface

Firefox | Normal | Define Normal at Dictionary...

dictionary.reference.com/browse/normal

define: normal

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Synonyms

acknowledged
conventional
traditional
commonplace
reasonable
accustomed
methodical

MORE Thesaurus.com

nor·mal [nawr-muh'l] Show IPA

adjective

1. conforming to the standard or the common type; usual; not abnormal; regular; natural.
2. serving to establish a standard.
3. *Psychology.*
   a. approximately average in any psychological trait, as intelligence, personality, or emotional adjustment.
   b. free from any mental disorder; sane.
4. *Biology, Medicine/Medical.*
   a. free from any infection or other form of disease or malformation, or from experimental therapy or manipulation.
   b. of natural occurrence.
5. *Mathematics.*
   a. being at right angles, as a line; perpendicular.
   b. of the nature of or pertaining to a mathematical normal.
   c. (of an orthogonal system of real functions) defined so that the integral of the square of the absolute value of any function is 1.
   d. (of a topological space) having the property that corresponding to every pair of disjoint closed sets are two disjoint open sets, each containing one of the closed sets.
   e. (of a subgroup) having the property that the same set of elements results when all the elements of the subgroup are operated on consistently on the left and consistently on the right by any element of the group; invariant.
6. *Chemistry.*
   a. (of a solution) containing one equivalent weight of the constituent in question in one liter of solution.
   b. pertaining to an aliphatic hydrocarbon having a straight unbranched carbon chain, each carbon atom of which is joined to no more than two other carbon atoms.
   c. of or pertaining to a neutral salt in which any replaceable hydroxyl groups or hydrogen atoms have been replaced by other groups or atoms, as sodium sulfate, Na_2SO_4.

COLLAPSE

Related Words

normalize
subnormal
completely normal
space
degenerate
fast motion
supernormal
tone
aberrant
aberration
basal metabolic rate
hybridoma
intermittent fever
MORE

Matching Quote

*"In a land which is fully settled, most men must accept their local environment or try to change it by political means; only the exceptionally gifted or adventurous can leave to seek his fortune elsewhere. In America, on the other hand, to move on and make a fresh start somewhere else is still the **normal** reaction to dissatisfaction and failure."*

-W.H. Auden

MORE

Record Low Mortgage Rates

FAVORITES RECENT search dictionary Search WORD DYNAMO How many words do you know? FIND OUT

We want the abnormal definition of normal...

start | 4 (Ch4) Forces | Microsoft PowerPoint ... | Outlook Today - Micr... | Normal | Define Norm... | 1:01 PM

Two Classes of Forces

Contact Forces

- Forces that happen only when two objects are touching- in some way or another

Field Forces

- Forces that can apply themselves over a distance- no contact between the objects exerting a force on each other needs to be made

Philosophy Question: What does it mean to "touch" something, if your electrons are really just repelling the object's electrons?

Holt Book– Ch4 Sec1

FREE BODY DIAGRAMS

Center of Mass

(or center of gravity for a uniform, or near-uniform, gravitational field)

- The mass of any object is distributed across its entire body, but this is often difficult to handle mathematically
- You can approximate all of an object's mass to be in one location- the center of mass
  - The center of mass can be calculated using the shape and density (a big calculus problem)
  - You can find it quickly by rotating an object, or trying to balance it on a fingertip
    - An object will not fall down as long as the center of mass is directly over or under the support that holds it up

General info for Free Body Diagram

- Free-body Diagrams are used to graphically represent all of the forces acting on a certain object. **The forces are represented as vectors.**
  - Objects are represented with a single dot
    - Pictures can be drawn around the dot to identify the object
  - Each force has its own vector
    - All vectors must be pointed radially outward from the dot
    - The direction of the vector indicates the direction of the force applied on the object
    - Multiple forces applied in the exact same direction can piggyback tip-to-tail
  - Force vectors can ultimately be broken down into X & Y components for algebraic analysis to find their sum
  - The overall acceleration of an object is the result of its net force (Σf_{net}), which is the sum of all forces acting on it

Develop a Free Body Diagram for the Pasco© fan-powered cart on a horizontal track

Free Body Diagram

Develop a free body diagram for a cannonball mid-flight

Free Body Diagram

Develop a free body diagram for a block sitting on a track

Free Body Diagram

Develop a free body diagram for a block sitting on an angled track

Free Body Diagram

After a skydiver jumps from a plane, the only force initially acting on the diver is Earth's gravitational attraction. After about ten seconds of falling, air resistance on the diver will have increased so that its magnitude on the diver is now equal in magnitude to Earth's gravitational force on the diver. At this time, a diver in a belly-down position will be falling at a constant speed of about 190 km/h.

a) Draw a free-body diagram of the skydiver when the diver initially leaves the plane.

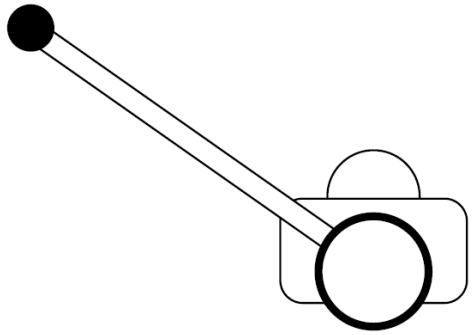
b) Draw a free-body diagram of the skydiver at the tenth second of the falling.

Practice Problem (Prac A #2)

A chef places an open sack of flour on a kitchen scale. The scale reading of 40 N indicates that the scale is exerting an upward force of 40 N on the sack. The magnitude of this force equals the magnitude of the force of Earth's gravitational attraction on the sack. The chef then exerts an upward force of 10 N on the bag and the scale reading falls to 30 N. Draw a free-body diagram of the latter situation.

Practice Problem (Prac A #1)

A music box within the toy shown below plays tunes when the toy is pushed along the floor. As a child pushes along the handlebars with a force of 5 N, the floor exerts a force of 13 N directly upward on the toy. The Earth's gravitational force on the toy is 10 N downward while interactions between the wheels and the floor produce a backward force of 2 N on the toy as it moves. Draw a free-body diagram of the toy as it is being pushed.



Practice Problem (Prac A #3)

Holt Book– Ch4 sections 2-3

NEWTON'S LAWS

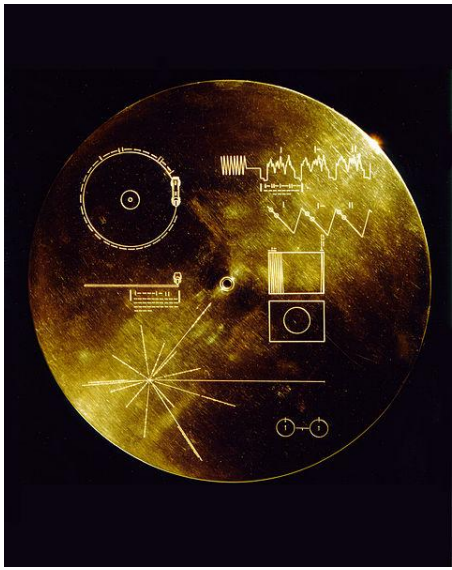
Newton's Laws

1. An object in motion will stay in motion and an object at rest will stay at rest, unless acted upon by an unbalanced force (Inertia)
2. $\Sigma F=ma$ [*Net force* = *Mass* x *Acceleration*]
   - *(The acceleration of an object is directly proportional to the force applied and inversely proportional to its mass)*
3. For every action there is an equal and opposite reaction [on another object]

- Original Document of Newton's Laws: *Philosophiæ Naturalis Principia Mathematica*
  - A work in three books by Sir Isaac Newton, first published on July 5, 1687

Newton's First Law (Inertia)

- An object in motion will stay in motion and an object at rest will stay at rest, unless acted upon by an outside force
  - An object has 'Inertia' that wants to keep moving in the exact same way if nothing was acting on it
  - Any net force- a push, friction, gravity, etc.- and only a net force will change the motion of an object
- Voyager I & II will continue on floating through space endlessly, unless a net force causes change

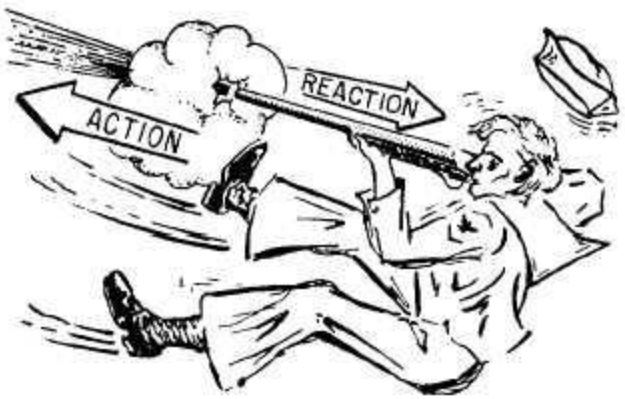


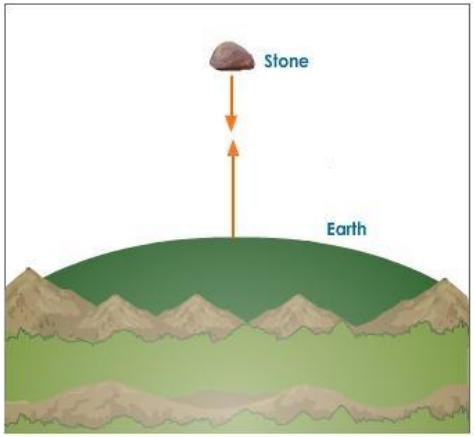
Newton's Second Law $\sum F = ma$

- ΣF=ma [*Net force* = *Mass* x *Acceleration*]
  - A net force is the cause of acceleration of objects
    - Acceleration will always be in the same direction as the net force
    - The symbol $\mathbf{F_{net}}$ is also used to represent net force
  - The word *Net* in *Net Force* refers to the fact that it is the sum (hence the sigma) of all forces acting on the object
    - So: ΣF=ma and $\Sigma F = F_1 + F_2 + F_3 + \ldots + F_n$
  - The net force is the force you can observe (or infer), when you see an object moving in a certain way.

Newton's Third Law (Equal-Opposite)

- For every action there is an equal and opposite reaction
  - All actions have some response in the universe- but not all of them will make it into a free body diagram
  - In free-body diagrams only include the forces acting on an object
    - Is the force on the stone the action or reaction?





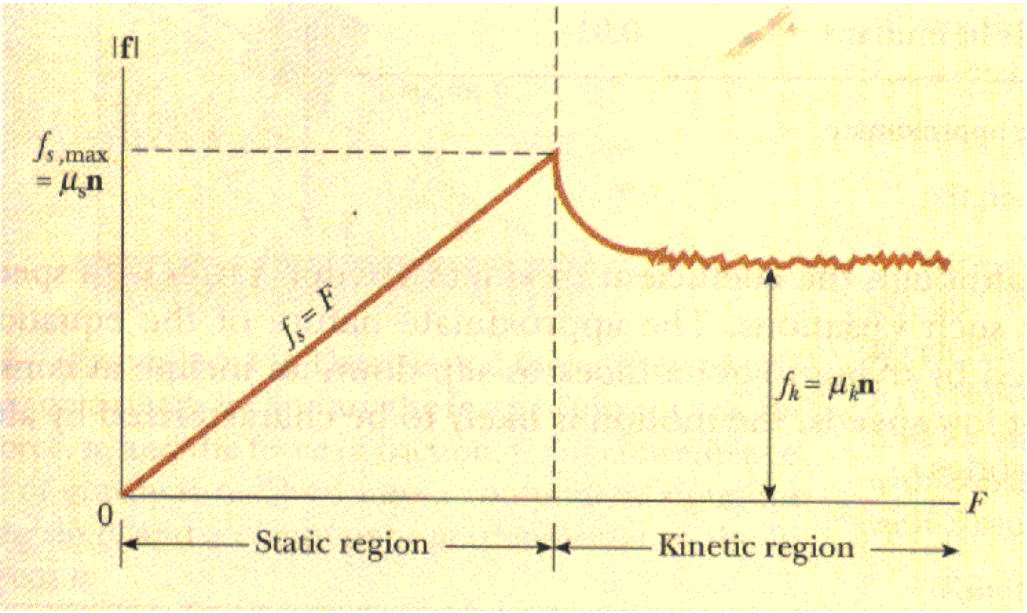
Technicalities on Gravity

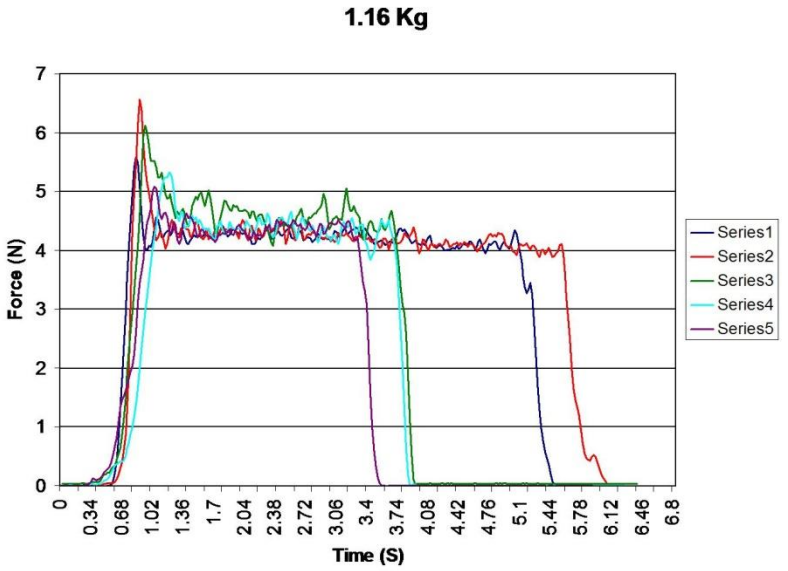
This is the most commonly missed idea in problems

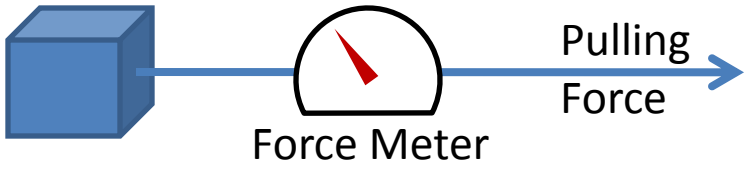
- Let's not mince words:
  - **<u>Mass and Weight are different things.</u>**
    - Weight is a force, applied by gravity, on an object
      - **$F_g=ma_g$ or $F_g=mg$** → weight is the force of gravity
    - Mass is the amount of matter present in an object
      - On Mars your mass is the same, but your weight is different
    - The Earth pulls on you just as much as you pull on the Earth
      - Every action has an equal and opposite reaction
      - Since Earth is so big, it is (presently) impossible to perceive your effect on its movement

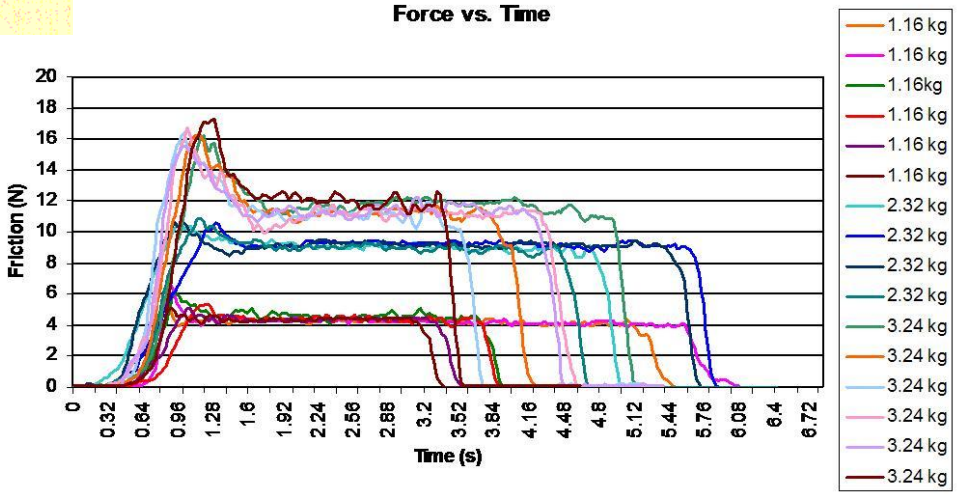
Interpreting Frictional Effects

These graphs show how the force required to pull something changed over time



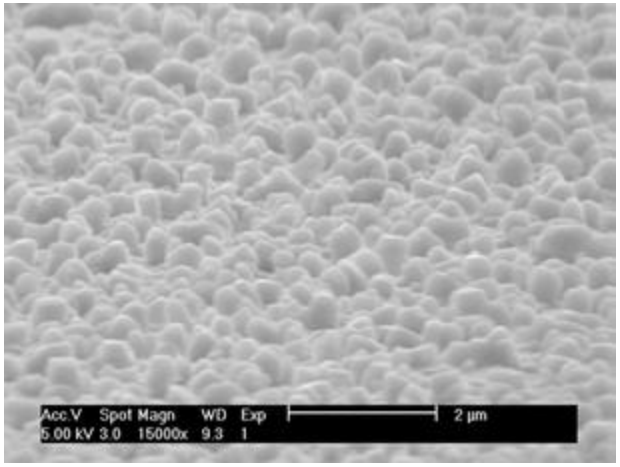


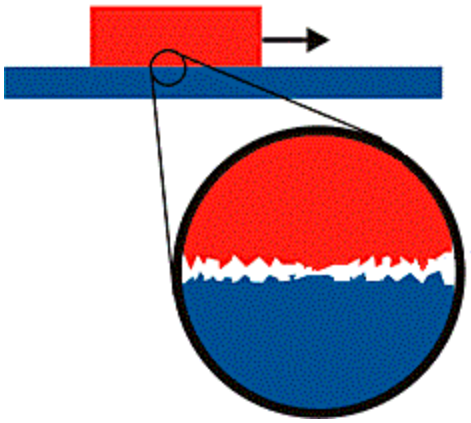




Kinetic Friction

- Kinetic Friction is the friction between two bodies moving relative to each other
  - Only applies once things are already moving
- Kinetic friction is described by: $F_k=\mu_k F_n$
  - A constant value* regardless of speed
  - Kinetic friction is conseptually much simpler than static friction
  - Kinetic Friction is always weaker than the maximum static friction





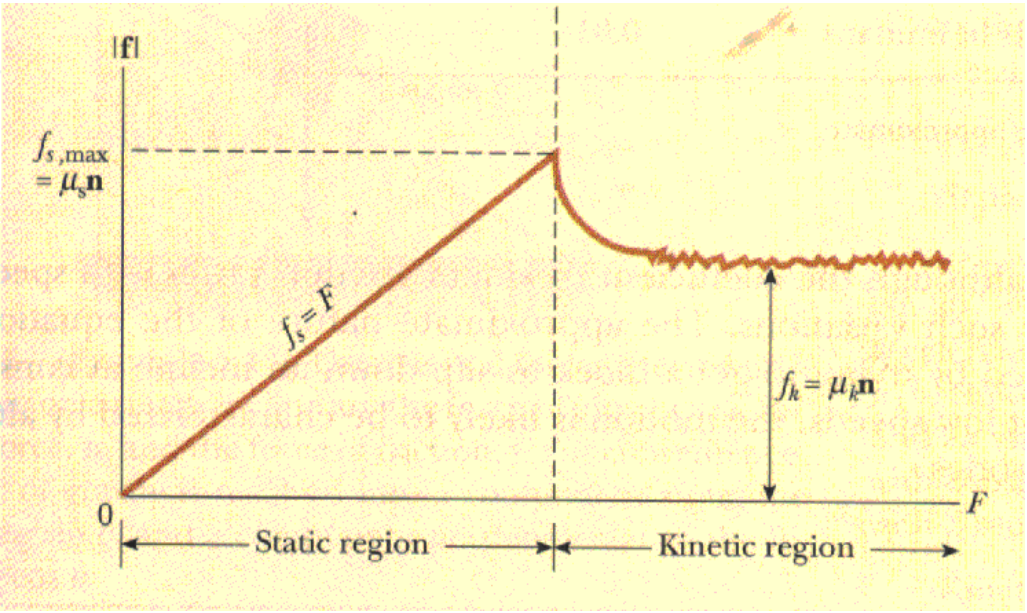
*There is some variation with speed (or a few other conditions) that we will ignore for our purposes here.

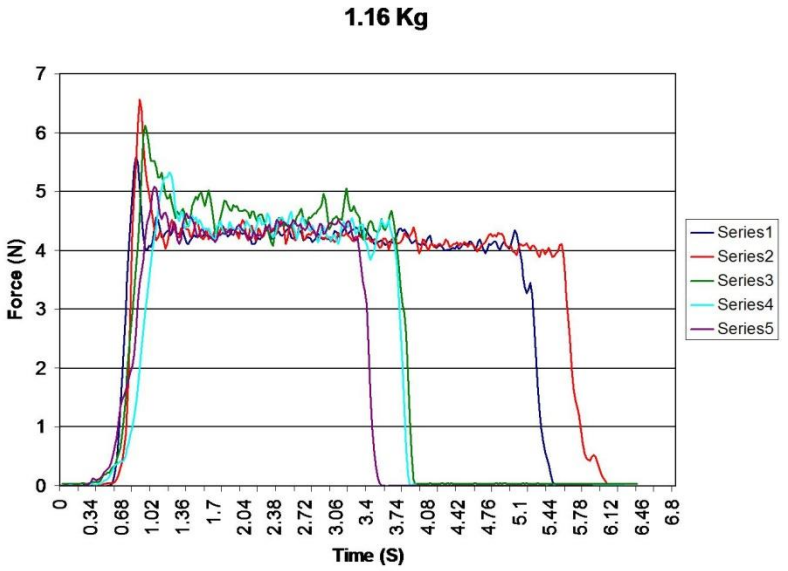
Static Friction

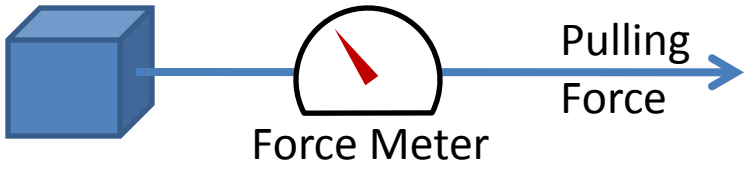
- Static friction is the friction between two surfaces, when those two surfaces are not already moving relative to each other, but are inclined to doing so by some other force
  - Static friction is difficult to spot, as its biggest physical sign is inaction
  - Consider this scenario: you push a refrigerator and it doesn't move. Why not?
- The maximum static friction can be calculated with: $\mathbf{F_{s(max)}=\mu_s F_n}$
  - F_n is the normal force acting on the object
  - μ_s is the *coefficient of static friction* (a rating for how frictional a pair of surfaces are, based on the force of friction and the normal)
  - The symbol $\mathbf{F_{s(max)}}$ is used because static friction has a variable value with a fixed maximum

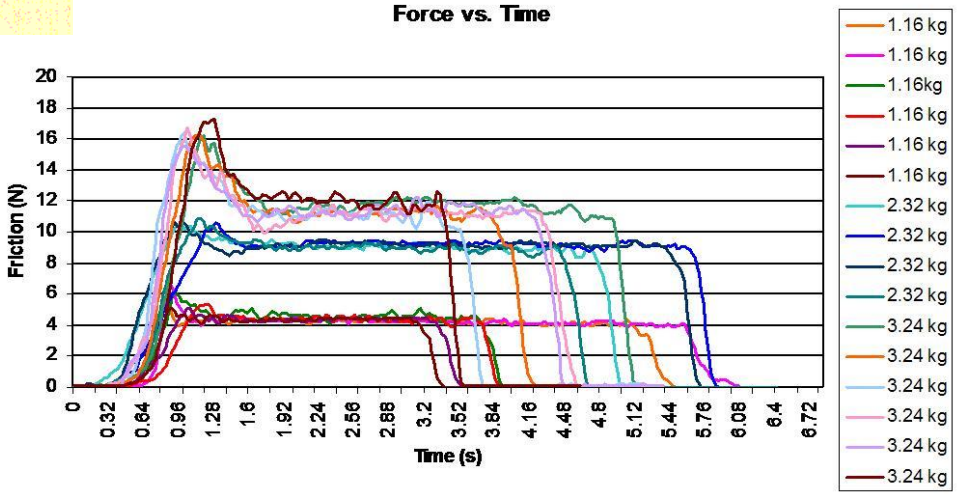
Interpreting Frictional Effects

These graphs show how the force required to pull something changed over time









Another look at Normal Force

- The normal force…
  - Is the force that a surface exerts onto an object sitting on it
  - is <u>always perpendicular to the surface</u>
  - Like static friction, normal has a maximum value and can vary in strength beneath that maximum
    - The maximum is the ‘breaking force’ of the surface
    - The normal can vary easily- stand on a bathroom scale and press down on a nearby sink, you’ll ‘lose weight?!’

*Not really. Why this effect?

Notes on Physics problems

- From this point (Forces Chapter) on there is a distinct difference in how physics problems will work. Kinematics was a process to learn.
  - Now the problems become less robotic, and more cognitively engaged
  - Situations need further broken down & assessed
  - Connections between items in the real world (or physics world) will occasionally need to be made to advance the math toward a solution

Block A is 100kg and on the table. Block B is 50kg and suspended from a mass-less string tied to Block A and run over a pulley. What is the acceleration of block B?

-Find force of gravity on B

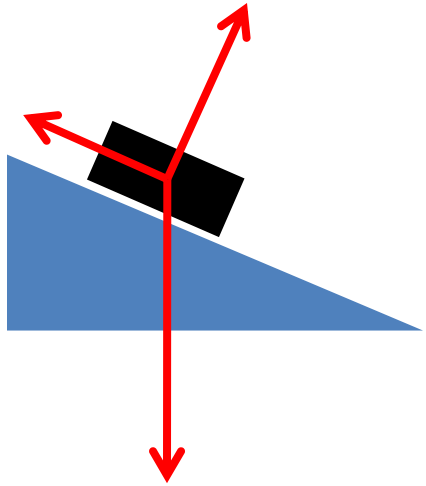
-Apply that force to the mass of A+B

-The acceleration of the A+B pair is the acceleration of just B as well

3.27 m/s² Down

Blocks and a Pulley

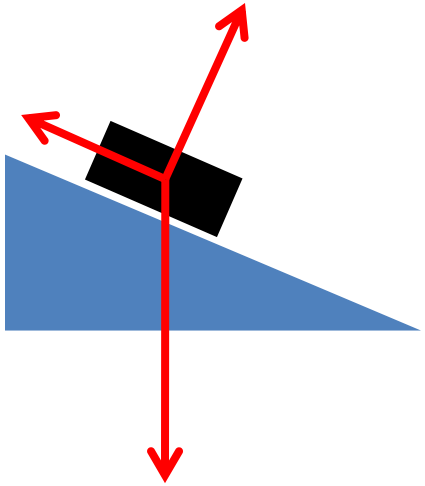
A Hummer can park on a road at a 41° angle and has a massof 3000kg. What is the coefficient of friction between the hummer and angled road?



Quick Lab Idea

Objective:

- Find the coefficient of static friction between an object and a board tilted up at the maximum angle where the object will not slide down the ramp



$$\mu_s = F_{s,max}/F_N$$

Holt Book Chapter 7 Section 2

UNIVERSAL GRAVITATION

Universal Force of Gravitation

- Gravity is the non-contact force that pulls all massive bodies together (it acts on all matter)

$$F_g = G\frac{m_1 m_2}{r^2}$$

  - G=gravitational constant= 6.673×10^{-11} Nm^2/kg^2
    - Mass of Earth= 5.974×10^{24} kg
    - Radius of the Earth= 6.378×10^{6} m
    - Mass of the Moon= 7.36×10^{22} kg

A Special Case of Universal Gravitation

- Universal gravitation applies everywhere, but most of the time we are used to seeing gravity where we live: the Earth's surface
  - Plugging in constants that describe the surface of the Earth can show the origin of the already familiar equation: $F_g=mg$

$$F_g = G\frac{m_1 m_2}{r^2} = m_1\left(\frac{Gm_2}{r^2}\right) = m_{object}\left(\frac{Gm_{Earth}}{(r_{Earth})^2}\right)$$

Start with the Equation

Rearrange so one mass is by itself

Put in values that describe an object near Earth's surface

$$F_g = m_{object}\left(\frac{\left(6.673\times10^{-11}Nm^2kg^{-2}\right)\left(5.974\times10^{24}kg\right)}{\left(6.378\times10^{6}m\right)^2}\right) = m_{object}\left(9.8\,{}^{m}\!/_{s^2}\right)$$

Place the actual values in the equation and solve…

…to find that $F_g=mg$

The sun has a mass of 1.98892×10^{30}kg, and the next closest star, Proxima Centari, has a mass of 2.45×10^{29}kg. If the two are 4.243 light years (4.02×10^{16}m) apart, what is the force of gravity each of them feels from the other?

2.012×10^{16} N

Two Stars (Real Values)

A stapler has a mass that is 1kg and a phone has a mass that is 2kg If a stapler and phone sit 0.25m apart on a desk, what is the force of gravity they exert on each other? Will this overcome the static friction?

2.14×10^{-9} N

Phone and Stapler on a Desk

Real Earth Gravity

Solve for F_g

The mass of the earth is 5.974×10^{24} kg, and a person's mass may be 90kg. If you can approximate the distance between the center of mass of the person and the Earth to be the 6.378×10^{6} m radius of the earth, what is the force of gravity acting on that person?

Prove g is not a fake

Enter into the equation for universal gravitation values for the mass and radius of the Earth, along with the gravitational constant. Then simplify this equation so that you have only one constant along with the variables for the unused mass and force. Does the result look familiar?