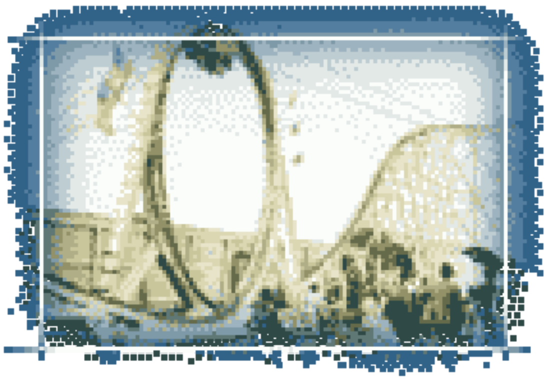
Physics Regular 1617 Williams

Rollercoaster Physics:

Forces & Circular Motion



<u>Newton's laws mini-lab</u>

Visit each station and understand how Newton's laws can explain their behavior. You may get a ***<u>lab quiz</u>*** *on it!*

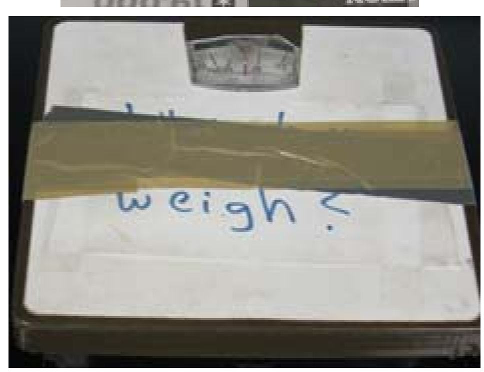
1. Magic Trick: To get the nuts to land in the flask, pull the hoop quickly. More nuts make it easier to do. Which law best explains this?

   What would happen if you pulled slowly?

2. With boxes A and B, one has much more mass than the other.
   a. Which one of Newton's laws predicts one is harder to begin moving from rest?
   b. Which one of Newton's laws would predict how much force would be required to give each a 1 m/s^2 acceleration?
   c. Push one so it slides along at constant speed. Are the forces on it balanced?
   d. How do you know?
   e. Draw a FBD showing all vertical and horizontal forces.

3. The old table-cloth trick....pull a paper from a full water bottle.
   a. Which one of Newton's laws explains this best?
   b. Using this same law, would it be easier or harder to do this trick with a very full or very empty bottle? Why?
   c. What force will tend to make the bottle tip over?

4. Cooperative pushing...push with a 10 lb. force with a partner.
   a. Can you do this without someone or something pushing back?
   b. Is it possible to have a single, isolated force?
   c. Which one of Newton's laws explains this best?



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ESPN Sport Figures: "That Mu You Do" with Jeff Gordon

1. What do they put in race car tires instead of air?

2. What are a couple of things that friction does to a car?

3. What is between the tires and the road that keeps the car under control?

4. What is the term for when a tire uses friction to grip the road?

5. Name two things that the force of friction depends on.

6. What do we call the characteristic that describes the amount of traction between two surfaces?

7. What are the two types of friction and what is the difference?

8. What symbol is used for the coefficient of static friction?

9. What is the unit for μ?

<u>Force Diagrams</u>

Free Body Diagrams (FBD)- Sketch the FBD for each situation

1. A box on a flat floor

2. A stationary box on a tilted ramp

3. A box sliding on a tilted ramp at constant speed

4. A box sliding on a tilted ramp accelerating

5. A sign held up by two evenly space chains

6. A sign held up by a long chain on the right and a short chain on the left

7. A parachutist as he just jumps from a plane

8. A parachutist in freefall

9. An astronaut on a space station is the same as one of these, which one?

Newton's Laws in a Nutshell

Newton's First Law (Inertia): In the absence of a net force, an object at rest stays at rest and an object in motion stays in motion at a constant speed in a straight line forever

This means: Things keep doing what they're doing unless there's a leftover force in some direction. If all forces balance, it keeps on keepin' on.

This also means: When F=0, a=o (Follows from F=ma.) If acceleration is zero, it cannot be speeding up, slowing down, or changing directions. Its velocity is constant!!

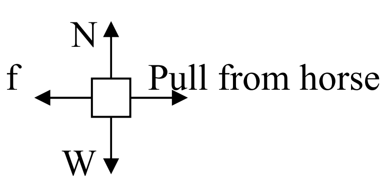
Newton's Second Law (F=ma):
A net force give a mass acceleration. Or, Net force = mass x acceleration.

This means: If there is a leftover force, things will change. It will speed up, slow down, or change directions. That is, it will NOT have constant velocity. Recall that velocity includes direction!

Newton's Third Law (action/reaction):
For every action there is an equal and opposite reaction.

This means: If two objects hit each other, they hit with the same force no matter what their masses or accelerations are. Always. These forces cannot cancel out even though they are the same amount and opposite directions because they aren't on the same object.

<u>Example</u>: A horse pulls a cart. The cart pulls the horse with the same force (but opposite direction) that the horse pulls the cart. Yet, the cart <u>can</u> move. Why don't they cancel out? Look at the cart's force diagram.



The fact that the horse has forces on him is <u>irrelevant</u> when trying to determine if the CART is moving. You must <u>only look at the forces on that</u> <u>one object</u> to see if it will change motion. So, if the force of the pull is greater than the force of friction, the cart moves. Otherwise it doesn't.

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Newton's Laws - which fits best/explain/understand?

1. In terms of inertia, what is the disadvantage of a lightweight camera when snapping the shutter? Why is a massive tripod preferred by most photographers?

2. Your empty hand is not hurt when it bangs lightly against a wall. Why is it so painful when you do the same action when carrying a heavy box?

3. In tearing a paper towel or plastic bag from a roll, why is a sharp jerk more effective than a slow pull?

4. What kind of motion does a constant force produce on an object of constant mass?

5. An object is not moving even though there was a force on it. What conclusions can you draw?

6. It gets progressively easier for a rocket to accelerate while it is in space. Why is this?

7. A Mack Truck and a VW bug have a head-on collision.
   a) Which has the greater force on it?

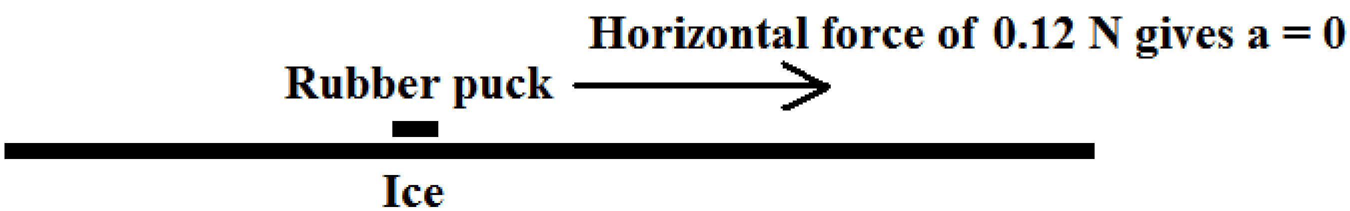
   b) Which has the greater mass?

   c) Which has the greater acceleration?

   d) Which has the greater damage?

8. A toy train with a single car launches a projectile straight up just before the train enters a tunnel along a straight track. Presuming the train does not change its velocity, will the ball land ahead of the train, behind it, or precisely on top of it?

Friction Practice Problems



Friction force: f = μN

There are two horizontal forces acting on the puck shown. First, a force is applied using a fish scale and it's found that when pulling the puck at **constant** velocity, a horizontal force of 0.12 N is indicated on the scale.

1. If the velocity is constant, what is the acceleration of the puck?

2. What is Newton's 2nd law?

3. According to Newton's 2nd law, if acceleration of anything is zero (say a hockey puck for instance), then what is the net force?

4. If the net force on the puck is zero and there is a horizontal force of 0.12 N to the right, then what left-ward force exists and what is its magnitude?

5. Assume the mass of the puck is 80 g, how many newtons does the puck weigh?

6. State the equation we learned for friction?

7. What is the normal force and what is its magnitude and direction for out example problem?

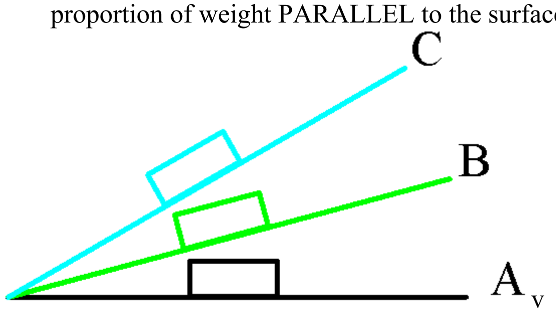
8. Do you have enough information to find the coefficient of friction of ice?

9. What is μ for the problem above?

10. In general, what do you know when acceleration is zero?

11. Check if you understand: Student A.J. applies a 12 N force to push a heavy box full of Lou Malnati's pizza across a table at a constant speed of 0.34 m/s. If the delicious large, buttercrust cheese pizza has a mass of 1800 g, then what is the experimental COF for cardboard/table surfaces?

12. Normal means perpendicular. The normal force is a REACTIONARY force perpendicular to the surface. As an inclined plane is tilted from position A to B to C (angle increases), what happens to the force proportion of the mass' weight pushing perpendicular to the surface? As the normal forces decreases, what happens to the friction force according to f = μN? What happens to the proportion of weight PARALLEL to the surface (the weight component trying to make it slide down)?



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FRICTION LAB

Introduction: Do they choose rubber as a material for tires because it has “high friction”? If that sounds logical, then consider this: Your rubber tires act very differently on wet ice in the winter than they do on a dry day. Obviously, the friction a tire experiences depends on what material the rubber tire is rubbing against.

Friction is a force that resists two objects from sliding by each other.It always acts opposite to the motoin of an object. In this lab we will investigate the effect of the type of materials that slide by each other as well as the effect of the normal force. Friction is also different depending on whether an object is sliding (already in motion), or is resisting a stationary object from beginning motion (static friction). Static friction is generally more than sliding friction and is never less. In other words: $F_{static} \geq F_{sliding}$.

Part I: Static vs. Sliding Friction: Effect of materials

You will using a sliding block, spring scale and a two weights for your investigation. Use your spring scale to find the weight of the block and the heavier weight. Newton’s 3rd law says that if an object is resting on a surface, that surface will exert a force equal to the weight of the object. This response force is perpendicular to the surface and we call this reactionary force the normal force since normal means perendicular. You are using a horiztonal surface so the normal force must be equal to the weight of the object. Coefficient of friction is is the ratio of the applied force to the normal force and uses the symbol: μ. μ is a property of two surfaces and has no meaning for a single surface. After all, how could you specify μ for rubber when rubber behaves so differently rubbing on ice compared to rubbing on dry pavement?

Method for measuring Static frictional force: Attach your spring scale to the sliding block. Pull the sliding block horizontally tugging harder and harder until the block moves. The highest reading you see on the spring scale is the force required to begin motion. This is the static frictional force.
Method for measuring Sliding frictional force: Attach your spring scale to the sliding block. Pull the sliding block at a constant speed so the spring scale is steady. This steady value is the force required to maintain motion so the frictional force exactly balances the force applied by the spring scale and F_{net} is zero. This is the sliding frictional force.

Record your data below and answer the questions:

$f_{static} = \mu_{static} * F_{Normal}$ $f_{sliding} = \mu_{sliding} * F_{Normal}$

Surfaces	Normal force (N)	Static Frictional force (N)	Sliding Frictional force (N)	μ_{static} (dimensionless)	$\mu_{sliding}$ (dimensionless)
Rubber/table					
Wood/table					
Rubber/carpet					
Wood/carpet					

1. Circle one: The frictional force always opposes the (applied force/motion)
2. The units for cofficient of friction are:
3. Circle one: The normal force is always (perpendicular to the surface/parallel to the motion/depends on the surfaces)
4. Can you tell what material pairing has the highest value for μ and if so, what is its value?

Part II: Static vs. Sliding Friction: Effect of normal force

Imagine placing a small child on a piece of carpet and pulling her across the living room floor. She is only moving horizontally, so you are not lifting her up, you are just applying a force to resist friction of the carpet against the floor. Now imagine putting a big football player on the same carpet. Would it be so easy to pull him along the floor? You haven't changed the materials for the coefficient of friction (μ) hasn't changed. Obviously, since you're resisting friction and friction has gone up, something else caused it to happen. It turns out that the normal force has an effect on frictional force. Investigate this relationship by varying both the normal force and the frictional force below.

Record your data below and answer the questions:

Percent more = 100% * (Heavy value – Light value)/Light value

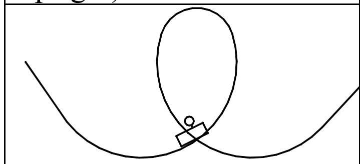
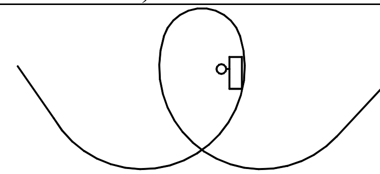
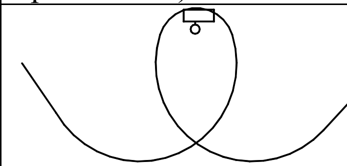
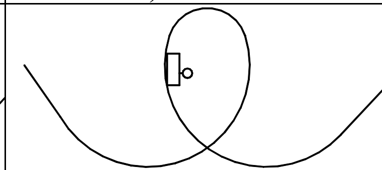
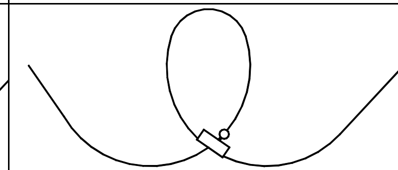
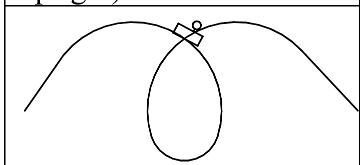
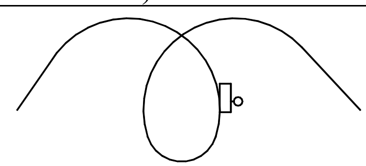
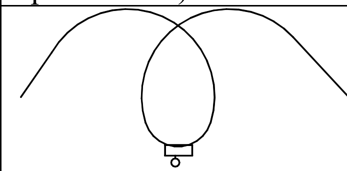
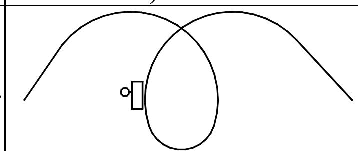
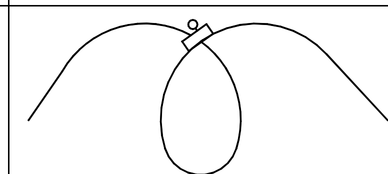
Surfaces	Light weight (N)		Heavy weight (N)		Percent more (%) Heavy compared to light	
	Normal force	Frictional force (sliding)	Normal force	Frictional force (sliding)	Normal force	Frictional force (sliding)
Rubber/table						
Wood/table						
Rubber/carpet						
Wood/carpet						

1. Which goes up more percentage-wise: Normal force or frictional force?

2. If the football player weighs six times that of the small child, how much harder would you have to pull the football player?

3. Draw a free body diagram of the football player and the child below showing both vertical and horizontal forces. Remember, magntude of force is shown by arrow length in free body diagrams.

4. Sketch the basic graph shape of frictional force versus normal force. Label the X and Y axes and point out the MEANING of the slope (hint: look at the equation for friction!)

Inside loop				
g's from v^2/r are positive	g's from v^2/r are positive	g's from v^2/r are positive	g's from v^2/r are positive	g's from v^2/r are positive
Add an extra g (he's upright)	Don't add extra g (he's horizontal)	Subtract an extra g (he's upside down)	Don't add extra g (he's horizontal)	Add an extra g (he's upright)
				
Outside loop				
g's from v^2/r are negative	g's from v^2/r are negative	g's from v^2/r are negative	g's from v^2/r are negative	g's from v^2/r are negative
Add an extra g (he's upright)	Don't add extra g (he's horizontal)	Subtract an extra g (he's upside down)	Don't add extra g (he's horizontal)	Add an extra g (he's upright)
				
Airplane		**Car**		
Nose up: Black out, **add** extra g (he's upright), use "a/9.8" & g's are positive	Nose down: Red out, **add** extra g (still upright), use "a/9.8" & g's are negative	Straight line: don't add g's (lateral g's), use "a/9.8"; pos. g's)	Circular track: don't add g's (lateral g's), use "a/9.8"; pos. g's), use v^2/r for a	

Rules for any time you're flinging blood to feet or brain (vertical g's)

Negative g's → red out (fling blood to brain), positive g's → blackout (fling blood to feet)

http://en.wikipedia.org/wiki/G-force: While tolerance varies, with g-forces towards the feet, a typical person can handle about 5 g (49m/s²) before g-loc, but through the combination of special g-suits and efforts to strain muscles—both of which act to force blood back into the brain—modern pilots can typically handle 9 g (88 m/s²) sustained (for a period of time) or more (see High-G training).

Resistance to "negative" or upward g's, which drive blood to the head, is much lower. This limit is typically in the −2 to −3 g (−20 m/s² to −30 m/s²) range. The subject's vision turns red, referred to as a red out. This is probably because capillaries in the eyes swell or burst under the increased blood pre

Wanted: New Super Coaster at Great America

Six Flags is looking for the next new coaster design. Your design submission will is thrilling yet safe. Klothoid loops are used and g-forces are between -0.5 g's and +3 g's. Dips and hill tops are too brief to be included in the g-force limitation. Also, in order to avoid costly whiplash lawsuits, your design must keep stopping accelerations at no more than 15 m/s^2. Remember, you must create a model coaster that will "wow" evaluators from Six Flags and get their attention.

Your coaster wheels are efficient and nearly frictionless. You may assume they are frictionless for all computations except for braking force and related computations (see rubric).

Look at the rubric to make sure you have thought through carefully all important considerations, but consider the following check list to help you in this process with your design team:

1. What scale will I use?
2. What will be my theme? My coaster's name?
3. When will we make up a good jingle to help sell the design?
4. What will the coaster model use as a bottom base and where do we get it?
5. How can we make sure all team members contribute fairly and also make sure we have redundancy in case someone gets sick or forgets to do something on time? (Supervisor who checks up on everyone, etc.)
6. Since part of the evaluation is using time wisely (in class), what can we do to make sure that we don't lose points for doing all our wok outside of class?
7. Do we have a means of double-checking our computations to make sure there are no errors?
8. Is every paper turned in double-checked by someone?
9. List anything else you can plan to do to make sure you have an awesome coaster model!

Coaster Requirements:

1. Coaster has at least 7 features (hills, turns, and loops), including at least one (klothoid) loop
2. Feature number, speed, radius elevation and g force are labeled for each of 7 features (exactly 7 labels! important!)
3. Calculations (see summary sheet, label (1-15 & F1 - F7) all 18 calculations; neat and easy to follow!)
4. For your required loop
    a. Check g-force at the top of the loop
    b. Check g-force at the bottom of the loop
    c. Report the most dangerous g-force

Roller Coaster Project Rubric

	Points earned/ Points possible	Excellent	Good	Fair	Poor
Coaster design/model 1. Ride is "thrilling" but SAFE! 2. Coaster g's range from -0.5 to +3.0 (except for <u>brief</u> hills and dips) 3. Model is realistic looking & is not a Single Rail (NO Monorails) 4. Roller coaster has visual appeal 5. Quality of work is high relative to competition 6. Contains 7 labeled features (loops, hills/dips, turns) 7. Name is on coaster itself and paperwork turned in on presentation day	**20**	All of the elements are present and high quality.	Elements present and some are of high quality.	Most elements are present. Quality needs work for some.	Elements missing and/or of low quality.
Calculations & documents For **<u>each feature</u>**, 1. All 7 **<u>labels</u>** included on coaster itself and appear correct. Labels include feature number, speed, elevation, radius and g-force. 2. Features summary sheet and makes sense 3. Detailed Calculations for 15 summary items and for 7 features is turned in and are neat and easy to follow 4. G-force for BOTH top of loop and bottom of loop done. Loop elevation at top and bottom recorded. 5. Braking distance calculated including KE at bottom and Braking force required 6. Power for first hill climb including climb time, first hill height and units for hp are used 7. Cost of energy and required horsepower correct	**20**	All of the elements are present and high quality.	Elements present and some are of high quality.	Most elements are present. Quality needs work for some.	Elements missing and/or of low quality.
Presentation 1. Sales pitch is at least 1 minute, no more than 3 minutes 2. Sales pitch is enthusiastic and appears sincere 3. Large colorful visuals (easy for executive board to see) 4. Entertaining name or jingle 5. Audience in involved, educated & entertained 6. All members of group are also polite audience members 7. All group members worked well during class time given	**10**	All of the elements are present and high quality.	Elements present and some are of high quality.	Most elements are present. Quality needs work for some.	Elements missing and/or of low quality.
Total points earned					

Features summary sheet:

1. Scale used (example: 100:1) ________________________
2. (Actual) Height of first hill on model (m): ______________
3. Climb time for first hill (s): _________________________
4. Coaster mass including passengers (kg) ________________
5. 1st hill motor (hp) : ___________ energy consumed by 1st hill (J, 100% eff.): ______________
6. (Actual) Track length (m) : __________________________
7. Frictional energy "losses"* (J): __________________________
8. Average ride elevation (m): __________________________
9. Average ride speed (mph):__________________________
10. Average ride speed (m/s):__________________________
11. Amount of time to load & unload riders (s) :____________
12. Rides per day: _____________
13. Monthly(**) energy cost to operate lift motor: $__________
14. KE left at ride's end* (J) ___________ Momentum at ride’s end* ___________
15. Braking distance (m) /force (N)**/acceleration: __________ ___________ ___________

Feature number	**Feature type** (loop top, loop bottom, turn, hill top, dip)	**IF loop: Is loop inside or outside?**	**Radius of curvature (m)**	**Elevation above ground level (m)**	**Show: circular g's + orientation g's = total g's (loop only, show g-force at loop top and loop bottom)**
F1					
F2					
F3					
F4					
F5					
F6					
F7					

* $\mu = 0.0135$, source: http://www.coaster101.com/2011/10/24/coasters-101-wheel-design/; only take friction into account for questions 7 and 14-15; ride’s end means immediately prior to initial brake application
** Assume 30 day month, park open from 10:00 AM until 7:00 PM and ride is never down for maintenance, etc:

14-01

Rollercoaster Physics

Newton's Laws & forces (including friction)

"If a" you gonna remember **Newton's laws**, you gotta have a way to remember

- Inertia – resistance to change in motion (AKA, mass)
  - A body in motion tends to stay in motion; a body at rest, tends to stay at rest (**1st law**)
- $F_{net} = ma$ (**2nd law**)
  - Rock star in the world of physics formulas
  - Understand all it implies: Bigger forces make bigger accelerations
  - For a given force, bigger masses mean less acceleration
  - Everything is linear (nothing squared)
  - Zero acceleration doesn't mean zero force...zero NET force
- Action/reaction pairs (**3rd law**)
  - The fun one....walls and floors can push you...what the????
  - For every action, there is an equal and opposite reaction
- You will need to memorize which law is which

Newton's laws examples

- You want to go left:
  - What way do you push on the ground?
  - What pushes YOU left?
- The lazy horse and his cart
- It's hard to stop/start a train, easy to stop/start a cart
- To produce an acceleration of 5 m/s^2 on a 60 kg mass, what force needs to be exerted?

Review what force and acceleration are

- A force is a push or pull that makes something accelerate (measured in Newtons)
- Acceleration is rate of change in velocity
  - What is velocity?
  - Does an object moving at constant speed:
    - In a straight line accelerate?
    - in a circle accelerate? (apply what you know carefully)

What is friction?

- A force that resists motion as two objects slide by each other
- It always acts opposite the motion (not necessarily opposite the net force, example?)
- A property of how easily TWO materials slide by each other is mu (not "moo", μ)
  - μ comes in two flavors: static and dynamic (μ_k, μ_s)
  - Static friction is usually more than dynamic friction (more force to start it moving than to continue its motion)
  - $F = \mu N$ is equation for frictional force, "fun" equation
  - N is how hard the surface pushes back on the object (3rd law)
  - For flat surfaces, N is ordinarily equal to the weight (mg)
- Which μ's are high, low, etc.?
  - Wet ice
  - Rubber
  - Plastic on ice
  - Rubber on concrete

Something you should know: μ_k vs. μ_s

ABS Braking systems

- $\mu_s > \mu_k$ so largest braking force is when tires are almost, but not quite skidding
- ABS brakes
  - Automatically pump brakes keeping static friction
  - Allow better steering – steer around obstacles
- https://www.youtube.com/watch?v=hwwXukJaTlM
- Does your car have ABS?

Example calculations

1. You push with 10 N of force on a 25 kg cart. The friction between the cart's wheels and the floor is 8 N. What is the cart's acceleration?
2. You slide a book across a desk and it goes 70 cm before stopping. You also know $\mu = 0.40$ between book and table. How fast did you slide the book originally? (use conservation of energy)

14-02

Rollercoaster Physics

G-forces & Circular Motion

Circular motion

- Do objects moving in circles have constant velocity?
- Tie a rope to a mass and whip it in a circle over your head.
  - Where does the force to change its direction come from?
  - Does the rope push or pull the mass? Toward what direction?
- "Centripetal" means "center seeking", centripetal acceleration/centripetal force
  - $a_c = v^2/r$
- What pushes a car on a track toward the center of the track?
- "Centrifugal" is an illusion

G-forces

- G-force is a ratio comparing an acceleration to gravitational acceleration
  - g's = acceleration/9.8
  - g's for circular motion is $(v^2/r)/9.8$
  - Shortcut to find V: V = sqrt(2gh)!
- Human considerations:
  - g's are positive when force is pushing blood to feet
  - g's are negative when force is pushing blood to head
  - how many g's do you have just standing there? How many would you have if you were standing on your head?
  - negative g's cause "red outs": are most dangerous since they can cause brain bleeds
  - positive g's cause blackouts
  - either can give people headaches, nauseas
  - keep g's in your coaster from -0.5 to +3.0 for safety

G-forces on a coaster

- G-forces are additive
- Add G-force from rider orientation to circular motion…that's all there is to it!
  - Orientation g's: upright = +1g, upside down = -1 g, sideways = don't add anything!
  - Circular motion g's: $(v^2/r)/9.8$: make positive if blood if flung to feet, negative if blood flung to head
- G-forces that are too high cause blackouts (not enough blood to brain)
- G-forces too low cause red-out, high blood pressure to brain: brain bleeds and death!
- Keep within -0.5 and +3.5 g's

Unit 14 Themed – Vocabulary and Equations – Circular Motion, Forces & Newton's Laws

$E_i = E_f$ (conservation of energy)
GPE = mgh KE = ½mv²
ME = KE + GPE Wt = mg
W = Fd P = W/t
AMA = F_o/F_i IMA = d_i/d_o
Eff. = W_o/W_i Eff. = P_o/P_i
f = μN F_{net} = ma $a_c = v^2/r$
$F_c = ma_c$ (circ.) g's = a_c/9.8
x = circumference = 2πr
v = $\sqrt{(2g\Delta h)} = \sqrt{(19.6\Delta h)}$

$v = \frac{\Delta x}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$
$\Delta x = v_0\,\Delta t + ½\,at^2$
$v_f^2 = v_i^2 + 2a\,\Delta x$ $v_f = v_0 + a\,\Delta t$
$\Delta x = v_x\,\Delta t$
$v_{yi} = v\sin\Theta$ $v_x = v\cos\Theta$
p = mv $p_i = p_f$
$(m_1v_1 + m_2v_2)_I = (m_1v_1 + m_2v_2)_f$
I = Δp = mΔv = FΔt

Equation	a	*t*	v_{yi}	v_{yf}	Δy
$v_{yf} = v_{yi} + at$	√	√	√	√	☹
$\Delta y = \frac{(v_{yi} + v_{yf})}{2}t$	☹	√	√	√	√
$\Delta y = v_{yi}t + ½at^2$	√	√	√	☹	√
$v_{yf}^2 = v_{yi}^2 + 2a\Delta y$	√	☹	√	√	√

1609 m = 1 mi	*60 mph = 27 m/s*	*1 hp = 746 W*	*1 lb = 0.4536 kg*	*1 mi = 1609 m*	*1 W-s = 1 J*	*1 ft = 0.3048 m*

Symbols:
Δ, x, v, t, Δv, Δt, a, f, i, $f_{s,max}$, f_k, F_g, a_c,
Vocabulary:
previous vocabulary
Newton (N), friction, normal force
coefficient of friction (COF, μ)
static friction, sliding friction,
kinetic friction
free body diagram (FBD),
Newton's law(s) (IFA)
centripetal, centrifugal,
tangential speed, centripetal acceleration,
centripetal force, circumference
g-force, black out, red out, klothoid loop,
center of mass

Unit Objectives - Williams

1. I understand all the vocabulary & math of this unit and all demos, videos, equations, and class assignments
2. I remember objectives & vocabulary from previous units.
3. I understand force is a push or a pull, and can distinguish contact and field forces such as gravity, magnetism and static electricity
4. I can draw/analyze free-body diagrams identifying F_N , F_g, F_A or F_T and F_f and analyze net forces
8. I understand that forces ON and object affect the motion of an object; forces BY and object do not
9. I realize that when all forces are balanced, the net force is zero and no acceleration takes place
10. I memorized all three Newton's laws by number. I can come up with examples of each kind and distinguish which law is primarily demonstrated when given sample questions.
11. That a floor can "push you" makes sense and this normal force is necessary or I feel weightless
12. I can compute weight, distinguish mass & weight, understand the universality of mass
13. I know friction always opposes the motion of an object and not necessarily the external forces on the object
14. I know how the normal force effects friction and how tilting surfaces changes normal and frictional force
15. I know what does/doesn't impact friction like μ, weight, normal force, motion, speed, contact area, etc.
16. I know what COF (μ) is, its units, how many surfaces determine it and how motion/stillness affects it
17. I know how the value for static friction varies with applied force, but kinetic friction is constant

<u>Circular motion, gravity</u>

1. I understand that circular motion requires a center-directed force
2. I know what blackouts and red outs are, how coasters produce them and how klothoid loops are used to combat them
3. I can look at circular motion examples and identify the source of centripetal forces
4. I know the difference between centripetal force and centrifugal force (inertia) and which one is real
5. I can use basic geometry knowledge to help solve circular motion problems
8. I understand the law of gravitation and gravity is a relatively weak force, but is only capable of attraction
9. I know that a normal force is required to feel weight as experienced in elevators and by astronauts

DuPage ROE Objectives

101. I can distinguish between scalar and vector quantities.
201. I can draw a free body diagram.
202. I can identify the Law of Inertia (Newton's 1st Law) to various situations in the real world.
203. I can add force vectors graphically to find net force.
204. I can distinguish the difference between mass from weight.
205. I can recognize net force as the sum of the forces and not a force in itself.
206. I can calculate the net force based on the forces acting on an object in one dimension.
207. I can determine if an object will accelerate depending on the net force acting on it.
208. I can solve problems using Newton's 2nd Law
209. I can identify action-reaction force pairs (Newton's 3rd Law) and the fact that they act on two separate bodies.
210. I can identify the factors that create friction, and how friction will affect an object's motion.
211. I can identify the direction of the velocity, acceleration, and net force on an object in uniform circular motion

<u>Newton's laws G-forces & Circular Motion: 2016-17 (Williams)</u>

Bold and underlined means put in journal notes.

1	**Th:04/06/17**	• Show Rollercoaster Project relating to Circular Motion & G-forces (description and rubric on website) • **(14-01)** notes (finish tomorrow if necessary); HW time?	• H14-01
2	**Fr:04/07/17**	• Finish (**14-01**) notes?; Discuss coaster project (due 5/21) • Newton's law lab	• H14-02
3	**Mo:04/10/17**	• μ video, Lazy horse; group work/quiz	• H14-03
4	**Tu:04/11/17**	• FBD in pkt; friction practice (pkt); • Clickers, Moodle?	• H14-04
5	**We:04/12/17**	• Sliding block lab & HW/Moodle time	• H14-05
6	**Th:04/13/17**	• Test review	• Study for test
7	~~**Fr:04/14/17**~~	• TBD: Non-attendance day (unless emergency day is used)	•
8-LS	**Mo:04/17/17**	• Forces & friction quest (~ 70 pts)	•
9	**Tu:04/18/17**	• **(14-02)** notes + water bottle class demo; coaster g-forces	• H14-06
10	**We:04/19/17**	• Overall coaster calculation example in class (finish tomorrow); HW time	• H14-07
11	**Th:04/20/17**	• Finish coaster calculation; Klothoid loops; g-force mastery; clickers?	• H14-08
12	**Fr:04/21/17**	• Fire Drill, 2:15 PM • Whole class circular motion computation (whirl something in a circle) • HW time	• TBD
13-LS	**Mo:04/24/17**	• Test review (clickers, etc.)	• Study for test
14	**Tu:04/25/17**	• Circular Motion & G-forces Test (~60 pts)	•