14:00 - 20:00

Name: KEY

6.60

6.14

banked curve

AP1 UCM & Gravity Recitations Part 1

NAME ______________________ DATE ______________

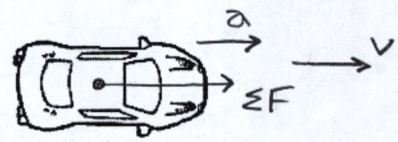
1

Scenario

Angela is in a stopped car at a traffic light when the light turns green and she accelerates.

Using Representations

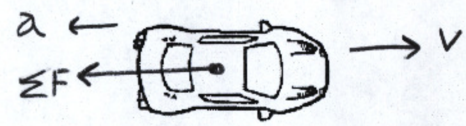
PART A: Sketch and label vectors for velocity, acceleration, and net force on the car. (This is NOT a free-body diagram.)



Which way does Angela's body "feel" pushed? Explain in a short sentence why she feels this way.

She feels pushed backed because her inertia is trying to keep her at rest while the car is moving forward.

PART B: As she approaches a stop sign, she slams on the brakes. Sketch and label vectors for velocity, acceleration, and net force on the car. (This is NOT a free-body diagram.)

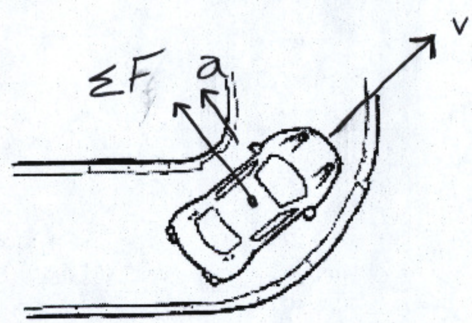


Which way does Angela's body "feel" pushed? Forward

Which way is the car accelerating? backward

Which direction is the net force on the car? backward

PART C: As Angela continues driving, she rounds a corner at a constant speed. Sketch and label vectors for velocity, acceleration, and net force on the car. (This is NOT a free-body diagram.)



Which way does Angela's body "feel" pushed? outward because she is trying to move tangent to the path.

Which way is the car accelerating? inward

Which direction is the net force on the car? inward

NAME ______________________ **DATE** ____________

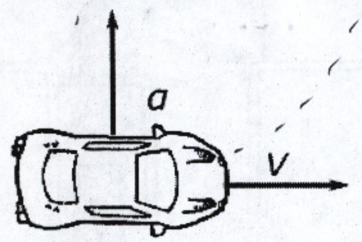
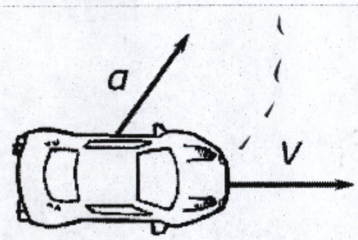
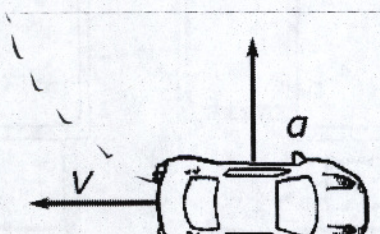
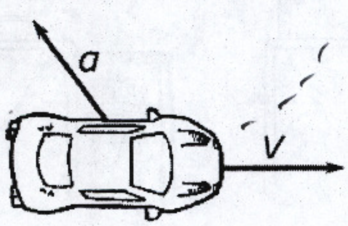
(2)

Scenario

A car is traveling along a long road. Air resistance can be ignored.

Using Representations

PART A: For the following situations, determine if the car is speeding up, slowing down, or staying at a constant speed and turning clockwise, counterclockwise, or not turning.

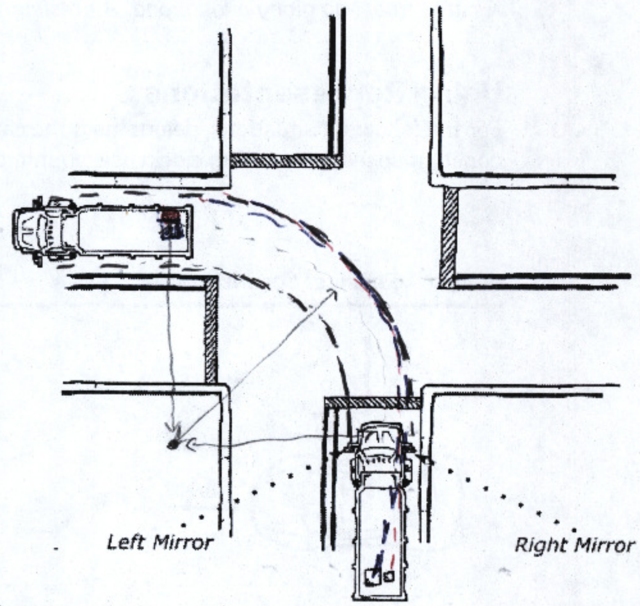
Physical Scenario	*Speeding Up/ Slowing Down/ Constant Speed*	*Turning Clockwise/ Turning Counterclockwise/ Not Turning*
	constant	turning counterclockwise
	speeding up	turning counterclockwise
	constant	turning clockwise
	slowing down	turning counterclockwise

NAME ______________________ DATE ______________

(3)

Scenario

A dump truck is making a very fast left turn as shown. In the back are two blocks of ice, one mass M *and one mass* m (M > m). *The truck does not roll over.*



Using Representations

PART A: Sketch the paths that the left and right mirrors take during the turn.

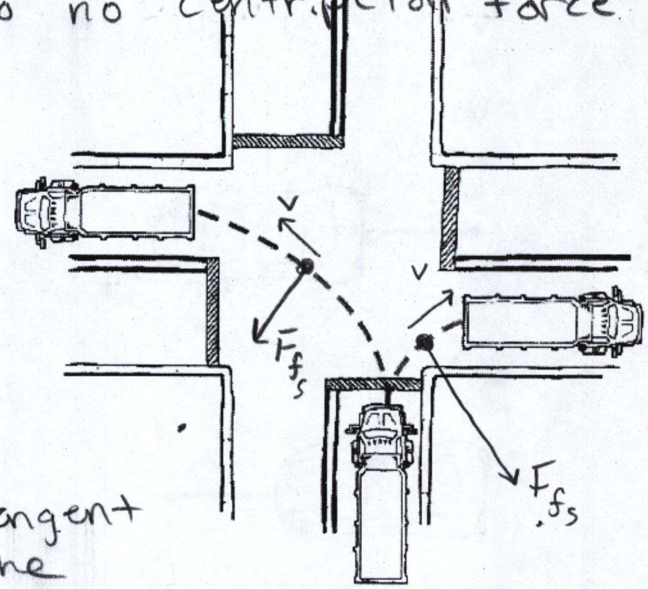
PART B: Using two different colors, sketch the paths that the two blocks of ice take during the turn. Assume that friction between the bed of the truck and the ice may be neglected.

Argumentation

PART C: Your friend, who is not in physics class, says the blocks go to the outside of the truck because a centrifugal force is acting on them. In a few brief sentences, explain why your friend is incorrect. Reference the diagram above in your answer.

latin
Centrifugal "away from center" force does not exist. The force is centripetal "toward center" and the blocks slide tangent to the circular path due to no centripetal force acting.

PART D: The truck then approaches another intersection to make a turn. The truck can either make a left turn or a right turn as shown in the diagram. Assume that the truck approaches, makes the turn, and continues in the new direction all without changing speed.



The centripetal force for the turn is provided by the force of static friction, which is determined by the relationship $F_{fs} = \mu_s F_N$. In a few short sentences, explain why the force of static friction, and not kinetic friction, is exerted on the truck even though the truck is in motion.

The force is static friction because the wheels don't slide tangent to the circle. If the force was kinetic then the car would be drifting.

To not slide

$\mu_s N \geq \frac{mv^2}{r}$

PART E: In a few short sentences, explain what happens if the value of $\frac{mv^2}{r}$ is greater than the value of $\mu_s F_N$.

$\Sigma F_c = ma_c$ $\Sigma F_c = m\frac{v^2}{r}$ $\mu_s N = \frac{mv^2}{r}$

If the required ΣF_c is greater than the static force of friction (max) then the car will slide as the force decreases to kinetic friction.

PART F: Which turn (left or right) requires the truck to slow down more in order to make the turn safely? Explain your answer using appropriate relationships.

The right turn has a smaller radius and this will require a greater centripetal force. The car will need to slow down since velocity has a squared relationship with ΣF_c.

$\Sigma F_c \uparrow \propto \frac{1}{r \downarrow}$

$\Sigma F_c \downarrow \propto v^2 \downarrow$

Checklist:

____ I answered the question directly.

____ I stated a law of physics that is always true.

____ I connected the law or laws of physics to the specific circumstances of the situation.

____ I used physics vocabulary (force, mass, acceleration, coefficient, velocity, speed, time, radius).

$\Sigma F_c = \frac{mv^2}{r}$

NAME ______________________ **DATE** ______________

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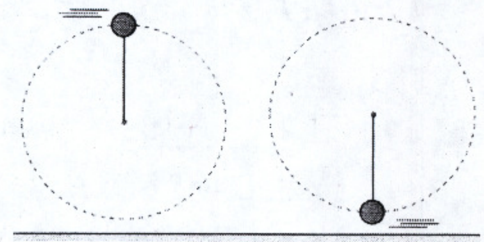
Scenario

A ball whose weight is 2 N is attached to the end of a cord of length 2 m as shown. The ball is whirled in a vertical circle clockwise. The tension in the cord at the top of the circle is 7 N, and the tension at the bottom is 15 N. Two students discuss the net force on the ball at the top of the circle.



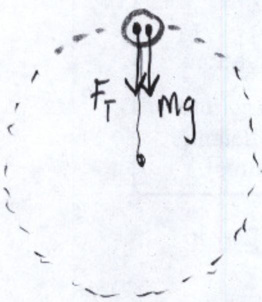
Dominique: "The net force on the ball at the top position is ~~7 N~~ since the ~~net force is the same as the tension.~~"

Carlos: "No, the net force on the ball ~~includes the centripetal force~~, tension, and weight. The tension and the weight are acting downward and have to be added. Then you need to figure ~~out the centripetal force~~ $\left(\frac{mv^2}{r}\right)$ ~~and include it in the net force.~~"

Analyze Data

PART A: Cross out the incorrect statements for each student's argument.

PART B: In a few short sentences, state the net force on the ball at the top of the circle and support your claim with evidence.



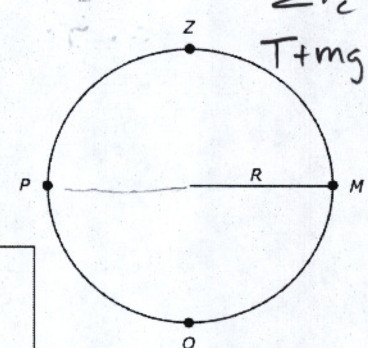
The net force at the top is equal to the sum of the tension and the weight which are both directed downward. This means the net force is 9N. This value is equal to $\left(\frac{mv^2}{r}\right)$.

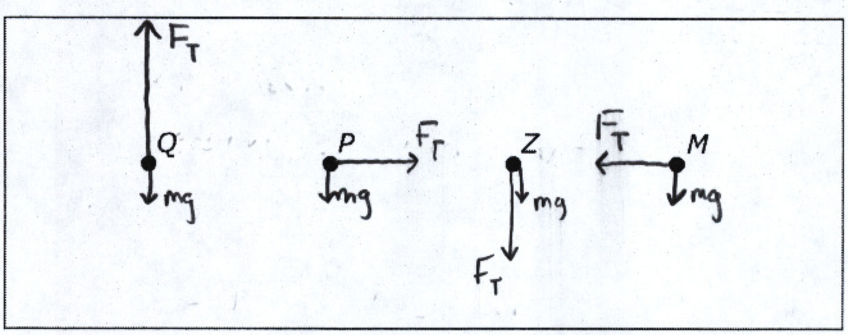
$\Sigma F_c = \frac{mv^2}{r}$

$T + mg = \frac{mv^2}{r}$

Using Representations

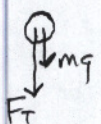
PART C: The diagram at right shows the circular path of the ball from Part A. The dots below represent the ball at the marked locations on the circular path. Draw free-body diagrams showing and labeling the forces (not components) exerted on the ball at each point. Draw the relative lengths of all vectors to reflect the relative magnitudes of all the forces.





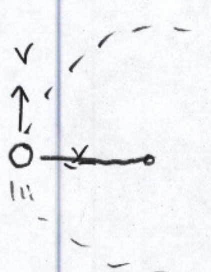
Quantitative Analysis

PART D: Derive an expression for the minimum speed the ball can have at point Z without leaving the circular path. For each line in the derivation, explain what was done mathematically. The first line is completed for you as an example.



$\sum F = ma_c$	The sum of the force is equal to *ma*, and since the ball is in circular motion, *a* is the centripetal acceleration.
$F_T = \varnothing$ $F_T + mg = ma$	At the moment the ball is at the top we want the string to just become slack to find the critical speed to just make it.
$mg = m\frac{v^2}{r}$	The only force now providing net force is the weight.
$g = \frac{v^2}{r}$	The mass cancels
$v = \sqrt{gr}$	

PART E: Suppose the string breaks at point P. Describe the motion of the ball after the string breaks. (When describing the motion of an object, you need to discuss what is happening to the position, velocity, and the acceleration of the object.) Tell the story of the motion of the ball from the time the string breaks until the ball reaches the ground.



Position:

The ball will not displace horizontally. The ball will hit the ground directly below point P.

Velocity:

The velocity is directed straight upward when the string breaks. The ball's velocity reaches zero and then increase downward until it hits the ground.

Acceleration:

The acceleration is "g" downward the entire time.

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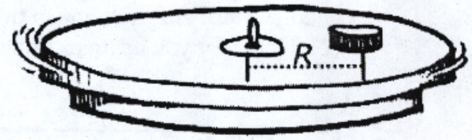
5

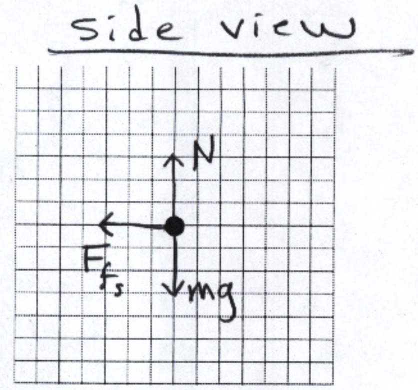
Scenario

Consider a coin of mass m placed on a rotating surface a distance R from the axis of rotation. The surface rotates with a period T. There are some locations on the surface where the coin can be placed and the force of static friction will not allow the coin to slip. At other locations, the coin will slip because static friction is not strong enough to prevent the coin from slipping. The coefficient of static friction between the coin and the surface is μ.



Using Representations

PART A: The dot at right represents the coin when the coin is at the location shown above in the diagram. Draw a free-body diagram showing and labeling the forces (not components) exerted on the coin. Draw the relative lengths of all vectors to reflect the relative magnitudes of all the forces. Each force must be represented by a distinct arrow starting on and pointing away from the dot.



Create an Equation

PART B: Starting from the equation $F_f \leq \mu F_N$, an inequality has been derived that must be satisfied at all times that the coin does not slip on the surface. The derivation has been done for you. You must fill in the annotations to explain each step.

$F_f \leq \mu F_N$	The force of static friction will always be less than of equal to $\mu_s N$ $F_{f_{s_{MAX}}} = \mu_s N$
$F_f \leq \mu mg$	The normal force in this problem is equal to the weight $\Sigma F_y = \emptyset$ $N - mg = \emptyset$ $N = mg$
$\frac{mv^2}{R} \leq \mu mg$	The static friction is providing the centripetal force.
$\frac{v^2}{R} \leq \mu g$	mass is directly proportional to both the centripetal force and the force of friction.
$v^2 \leq \mu gR$	Solving for v^2
$v \leq \sqrt{\mu gR}$	Solving for v
$\frac{4\pi^2 R}{T^2} \leq \mu g$	substituting $V = \frac{2\pi R}{T}$ into the above equation

$$\frac{2\pi R}{T} = \sqrt{\mu g R} \rightarrow \frac{4\pi^2 R^2}{T^2} = \mu g R$$

Argumentation

Blake and Carlos are trying to predict whether the coin will slip if the coin is "too close" to or "too far" from the axis of rotation. The students reason as follows:

Blake: "I think that the coin will slip if it is too close to the axis. It is like if a car takes a turn too tightly, the car can slide out of control. There's not enough force if the radius is too small.

Carlos: "I think that the coin will slip if it is too far from the axis. It's like a merry-go-round; if I ride a merry-go-round near the center, then I don't feel much force pulling me to the outside, but if I ride near the outside, there is more force pulling me away from the axis.

PART C: For each student's statement, state whether the inequality written in Part B provides support for that statement. If so, explain how. If not, explain why not. Ignore whether the student's statement is correct or incorrect for this part.

Blake's Statement	***Carlos's Statement***
Blake is supporting "too close" by indicating that radius has an inverse relationship with centripetal force ($\Sigma F_c \propto \frac{1}{r}$).	Carlos is supporting "too far" by saying he has experienced a greater (sensation) of being pulled outward from having a larger radius.

TRUTH: $\Sigma F_c = \frac{mv^2}{r}$ $v = \frac{2\pi r}{T}$ in this case.....

$\Sigma F_c = \frac{m}{r}\left(\frac{2\pi r}{T}\right)^2 = \frac{m4\pi^2 r^2}{r T^2} = \frac{m4\pi^2 r}{T^2}$ $\Sigma F_c \uparrow \propto r \uparrow$

PART D: State whether the coin will slip when it is "too close" to or "too far" from the axis.

_____ too close ✓ too far

PART E: Angela and Dominique are arguing over how the mass of the coin affects whether it will slip or not. Angela believes that a lighter coin is less likely to slip because a lighter coin requires less force. Dominique believes that a heavier coin is less likely to slip because a heavier coin can have a greater amount of friction. Using your equations along with other physical principles, explain how the coin's mass affects its likelihood of slipping.

It does not affect the situation.

$\Sigma F_c = m\frac{v^2}{r}$ $\mu_s mg = m\frac{v^2}{r}$

$F_{f_s} = m\frac{v^2}{r}$ $\mu_s g = \frac{v^2}{r}$ (mass cancels out)

$\mu_s N = \frac{mv^2}{r}$

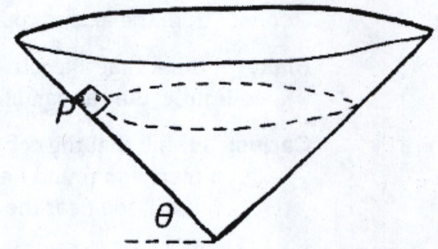
more mass = more centripetal force

more mass = more friction

NAME ______________________________ **DATE** ______________

Scenario

Consider a cone made of a material for which friction may be neglected. The sides of the cone make an angle θ with the horizontal plane. A small block is placed at point P. In Case 1, the block is released from rest and slides down the side of the cone toward the point at the bottom. In Case 2, the block is released with initial motion so that the block travels with constant speed along the dotted circular path.



Data Analysis

PART A: In Case 1, the block is released from rest. Is the block accelerating?

______ Yes ______ No

Explain, and if yes, determine the direction of the acceleration.

____

____

____

In Case 2, the block is released so that it travels with a constant speed along the dotted circular path. Is the block accelerating?

______ Yes ______ No

Explain, and if yes, determine the direction of the acceleration.

____

____

____

____

Using Representations

PART B: In both diagrams below, the weight F_g of the block is drawn. Draw the normal force exerted in each case on the corresponding diagram. Use the grids provided to make each normal force have the proper length. (In each case, breaking one of the forces into components will help you find the direction of the acceleration.)

Case 1	***Case 2***