Name:_____ ID:_____

Physics 201 | Ecampus

Midterm Exam 2

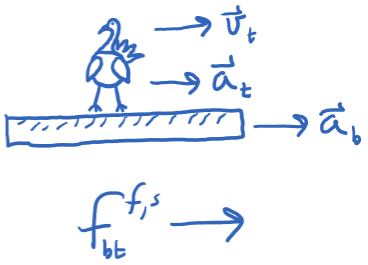
11/10/2021

Collaboration is not allowed. Allowed on your desk are: ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating graphing scientific calculator, 1 page of scratch paper, writing utensils, and the exam. You will have 80 minutes to complete this exam and 10 additional minutes to take a picture and upload your work to Gradescope.

1. (9 points) State whether each of the following statements is true or false. If true, describe a situation in which the statement is true. If false, describe a situation in which the statement is false. Use words, diagrams, symbols, etc...

(a) The velocity of an object and the force of friction on the object always point in opposite directions.

false,

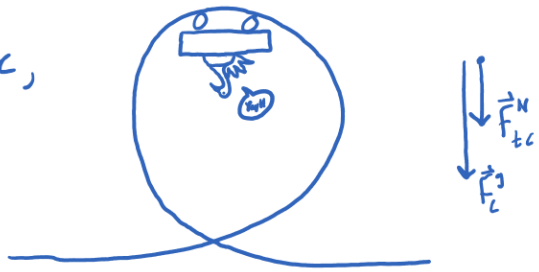


(f^f is always opposite the direction of relative velocity)

A turkey standing on a block which is accelerating to the right, from rest, will feel a force of friction to the right & also have a $\vec{v}$ to the right.

(b) The normal force on an object and the gravitational force on an object are always of equal magnitude and point in opposite directions.

false,

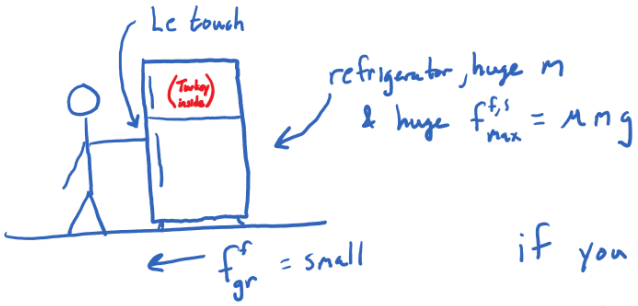


the force of gravity on a roller coaster car is pointed down.

the normal force from the track on the car is also pointed down and is almost certainly not the same magnitude as f^g (f^N depends on speed of car here)

(c) The static frictional force on an object can be less than $\mu_s * F^N$.

True,



Small = f^{touch} →

if you lightly touch a refrigerator the force of static friction on the ground will be in the opposite direction, but will also be small

$\mu_s F^N$ = maximum $f^{f,s}$

For questions 2 through 4 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **7** correct answers in this section and only the first **7** filled in answers will be graded. There is no partial credit.

2. Consider an object undergoing uniform circular motion. Which of the following statements must be **true**?

□ (a) The object has a constant velocity and acceleration.
X (b) The object has a constant magnitude net force acting on it.
X (c) The object is traveling in a circle of constant radius.
□ (d) The object must have a force pointing directly towards the center of the circle.
X (e) The object could have a force pointing directly outwards from the center.

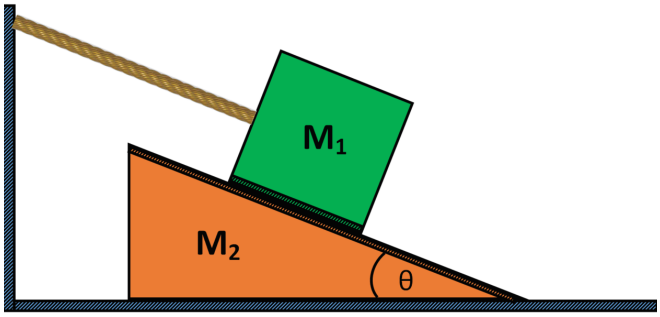
3. Which of the following statements must be **true**?

□ (a) Third law force pairs point in the same direction.
X (b) Third law force pairs are equal in magnitude.
□ (c) Third law force pairs must both act on the same system.
□ (d) Third law force pairs describe the interaction only between systems that are physically touching.
□ (e) Sometimes a singular force can exist without a third law force pair.

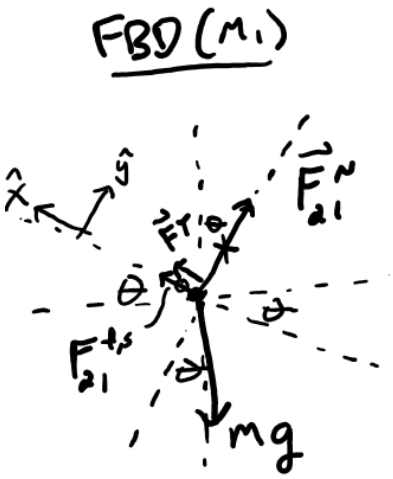
4. A Lion throws an American football at an angle of 23 degrees above the horizontal with an initial speed of 20 m/s. A few seconds later, a Cowboy catches the ball at the same height from which it was thrown. Which of the following statements must be **true**?

□ (a) The ball's velocity before it is caught is 20 m/s.
X (b) The vertical displacement of the ball from the throw to the catch is zero.
□ (c) At the top of the ball's motion, the ball's velocity is zero.
□ (d) At the top of the ball's motion, the ball's acceleration is zero.
□ (e) The ball's acceleration is positive before it reaches the top of its motion, and negative afterwards.
X (f) The speed of the ball just before it is caught is 20 m/s.
X (g) The acceleration of the ball, during the entire time it's in the air, points vertically downwards.

5. (12 points) Consider the situation in the figure where a square block ($\mathbf{m_1}$) sits stop a triangular wedge ($\mathbf{m_2}$). A rope is fixed to a wall and attached to the block such that the rope is parallel to the surface of the wedge. The wedge's top surface makes an angle of theta with respect to the horizontal. Assume that all surfaces have friction with the same static coefficient $\boldsymbol{\mu_s}$. The system is in equilibrium but if the coefficient of friction between the block and wedge was any smaller, they would slide relative to each other. The block ($\mathbf{m_1} = \mathbf{m}$) has a mass half as large as the wedge.



(a) Draw a free body diagram for $\mathbf{m_1}$.



(b) Use a coordinate system with positive x up the incline and positive y perpendicular to the wedge's incline. Write out Newton's 2nd law in both the x and y directions for box $\mathbf{m_1}$. Your answer should be in terms of $\mathbf{m}$, $\boldsymbol{\theta}$, $\mathbf{F^T}$, $\boldsymbol{\mu_s}$, $\mathbf{F^N_{(21)}}$, and $\mathbf{g}$. Identify any quantities that are zero. There is no need to solve for anything (i.e. don't solve for a variable in one direction and plug it into the other direction).

$$\sum F_x = ma_x$$

$$F^T + \mu_s F^N_{21} - mg\sin\theta = m\cancel{a_x}^{0}$$

$$\sum F_y = ma_y$$

$$F^N_{21} - mg\cos\theta = m\cancel{a_y}^{0}$$

~~~ Rubric ~~~

Part (a) - 2 points
- 0.5 pts - each correct force

Part (b) - 3 points
- 1.5 pts - Fnet in the x-direction
- 1.5 pts - Fnet in the y-direction

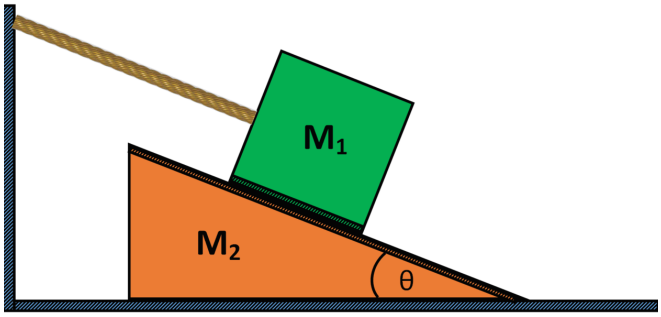
Part (c) - 1 point
- 0.5 pts - each 3rd law force pair

Part (d) - 2.5 points
- 0.5 pts - each correct force

Part (e) - 3.5 points
- 2 pts - correct 2nd law consistent w/ FBD
- 1.5 pts - component analysis in rotated coordinate system

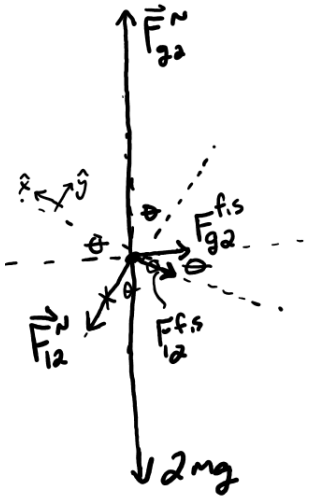
Problem 5 continued on next page...

5. (...continued) Consider the situation in the figure where a square block ($\mathbf{m_1}$) sits stop a triangular wedge ($\mathbf{m_2}$). A rope is fixed to a wall and attached to the block such that the rope is parallel to the surface of the wedge. The wedge's top surface makes an angle of theta with respect to the horizontal. Assume that all surfaces have friction with the same static coefficient μ_s. The system is in equilibrium but if the coefficient of friction between the block and wedge was any smaller, they would slide relative to each other. The block ($\mathbf{m_1} = \mathbf{m}$) has a mass half as large as the wedge.



(c) Draw a free body diagram for $\mathbf{m_2}$.

FBD (M_2)



(d) Identify all Newton's 3rd law force pairs between the box and the triangle wedge.

Force Pairs $\vec{F}^N_{21} = -\vec{F}^N_{12}$, $\vec{F}^{f,s}_{21} = -\vec{F}^{f,s}_{12}$

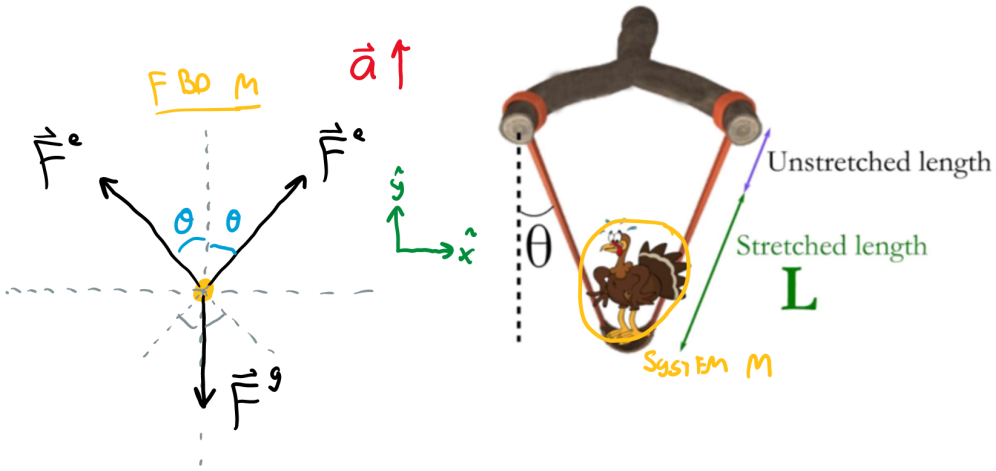
(e) Use a coordinate system with positive x up the incline and positive y perpendicular to the wedge's incline. Write out Newton's 2nd law in both the x and y directions for triangle $\mathbf{m_2}$. Your answer should be in terms of $\mathbf{m}$, $\boldsymbol{\theta}$, μ_s, $\mathbf{F^N_{(12)}}$, $\mathbf{F^N}_{(\text{ground},2)}$ and $\mathbf{g}$. Identify any quantities that are zero. There is no need to solve for anything (i.e. don't solve for a variable in one direction and plug it into the other direction).

M_2

$\Sigma F_x \Rightarrow F^N_{g2}\sin\theta - 2mg\sin\theta - F^{f,s}_{g2}\cos\theta - \mu_s F^N_{12} = 2m\cancel{a_x}^{\,0}$ (with $F^{f,s}_{g2} = \mu_s F^N_{g2}$)

$\Sigma F_y \Rightarrow F^N_{g2}\cos\theta + F^{f,s}_{g2}\sin\theta - 2mg\cos\theta - F^N_{12} = 2m\cancel{a_y}^{\,0}$

6. (6 points) At the annual Thanksgiving Turkey Launch, a contestant built a large sling shot that will launch a 8.00-kg Turkey vertically into the air near the surface of the Earth. The slingshot is made with elastic rubber bands connected to a wooden support. Similar to tension in a rope, each elastic rubber band provides a force along the direction it is oriented. Unlike a rope, each elastic band stretches from an unstretched length by a distance **L**, the stretch length. The magnitude of the force from each elastic band is given by the model: $\mathbf{F}^e = \mathbf{k}*\mathbf{L}$, where $\mathbf{k}$ = 42 N/m and **L** is the stretch length of 2.50 meters. What is the acceleration of the turkey when the elastic bands have a stretched length of 2.50 meters? Both elastic bands make an angle of 20 degrees with respect to the vertical.



$\Sigma F_y = Ma_y$

$F^e\cos\theta + F^e\cos\theta - Mg = Ma_y$

$\mathbf{2F^e\cos\theta - Mg = Ma_y}$

$\mathbf{2KL\cos\theta - Mg = Ma_y}$

$\Sigma F_x = Ma_x^{\,0}$

$F^e\sin\theta - F^e\sin\theta = 0$

$F^e = F^e$ ✓

$2\left(42\frac{N}{m}\right)(2.5\,m)\cos(20°) - (8\,kg)\left(9.8\frac{m}{s^2}\right) = (8\,kg)a_y$

$2(105\,N)\cos(20°) - 78.4\,N = (8\,kg)a_y$

$2(98.67\,N) - 78.4\,N = (8\,kg)a_y$

$197.3\,N - 78.4\,N = (8\,kg)a_y$

$118.9\,N = (8\,kg)a_y$

$a_y = 14.8625\ m/s^2$

$\boxed{a_y = 14.9\ m/s^2}$

Question 6 Rubric

Question part	Points	Description
Forces	1.5 pts	High Level Force Identification: Only 3 correct forces identified.
Forces	1.0 pt	Mid Level Force Identification: Only 2 correct forces identified. **.OR.** Extra forces identified in addition to the correct 3.
Forces	0.5 pt	Low Level Force Identification: Only 1 correct force identified.
Forces	0.5 pt	Correct definition for the magnitude of force of gravity.
Forces	0.5 pt	Correct substitution for the magnitude of elastic force.
Forces	0.5 pt	Acceleration in horizontal direction = 0.
Forces	1.5 pt	High Level Newton's 2nd Law Application: 2nd law in vertical direction consistent with FBD.
Forces	1.0 pt	Mid Level Newton's 2nd Law Application: 2nd law in vertical direction not consistent with FBD (missing a force or an angle).
Forces	0.5 pt	Low Level Newton's 2nd Law Application: 2nd law in vertical direction missing a lot.
Math	1.0 pt	High Level Algebra: Plugs in correct values for correct quantities, divides by mass correctly, etc…
Math	0.5 pt	Mid - Low Level Algebra: Values not plugged into correct locations, division by mass not done properly, etc…
Math	0.5	Correct answer.