CTNA-1. An Atwood's machine is a pulley with two masses connected by a string on a massless pulley as shown. The mass of object A, $m_A$, is twice the mass of object B, $m_B$. The tension $T$ in the string on the left, above mass A, is...

A) $T = m_A \ g$

B) $T = m_B \ g$

C) Neither of these.

Answer: neither of these. Mass A is accelerating downward, so the net force on A must be downward, so $m_A \ g > T$. Similarly mass B is accelerating upward, so it must be that $T > m_B \ g$. A key idea is that the magnitude of the tension $T$ is the same on both sides (only true if pulley is massless).

CTNA-2. Given the following two equations,

\[ A + B = C \]
\[ D + E = F \]

which of the following two equations are correct?

I. $A + B + D + E = C + F$
II. $A + B + F = C + D + E$

A) Both are correct
B) Neither are correct
C) Only one of these is correct

Answer: Both of these are correct.
CTNA-3. A mass m is pulled along a frictionless table by a constant force external force $F_{\text{ext}}$ at some angle above the horizontal. The magnitudes of the forces on the free-body diagram have not been drawn carefully, but the directions of the forces are correct.

Which statement below must be true?

A) $N < mg$
B) $N > mg$
C) $N = mg$

Answer: $N < mg$  The vertical component of $F_{\text{ext}}$ is helping to hold up the weight of the mass, so N is smaller than mg. In detail: Since $a_y = 0$, we must have $\Sigma F_y = 0$. Taking up as the $+y$ direction, we have $N + F_{\text{ext}} \sin \theta - mg = 0$, $N = mg - F_{\text{ext}} \sin \theta$. 
CTNA-4. A mass $m$ is accelerates downward along a frictionless inclined plane. The magnitudes of the forces on the free-body diagram have not been drawn carefully, but the directions of the forces are correct.

Which statement below must be true?
A) $N < mg$  B) $N > mg$  C) $N = mg$

Answer: $N < mg$

A student chooses a tilted coordinate system as shown, and then proceeds to write down Newton's 2nd Law in the form $\sum F_x = ma_x$, $\sum F_y = ma_y$. What is the correct equation for the $y$-direction $\sum F_y = ma_y$?

A) $N - mg \sin \theta = ma$  B) $N - mg \cos \theta = ma$
C) $mg \sin \theta = ma$  D) $N - mg \cos \theta = 0$
E) $N + mg = ma$

Answer: $N - mg \cos \theta = 0$
CTNA-5. A car of mass $m$, traveling at constant speed, rides over the top of a hill.

The magnitude of the normal force $N$ of the road on the car is...
A) greater than the weight of the car, $N > mg$.
B) equal to the weight, $N = mg$.
C) less than the weight, $N < mg$.

Answer: $N < mg$  The acceleration of the car is downward (toward the center of the circle) so the net force must be downward, so the downward force must be greater than the upward force.
CTNA-6. A rider in a "barrel of fun" finds herself stuck with her back to the wall. Which diagram correctly shows the forces acting on her?

Answer: A  Since the acceleration vector is toward the center of the circle, the net force must be toward the center of the circle.
CTNA-7. A bucket containing a brick is swung in a circle at constant speed in a vertical plane as shown. The bucket is swung fast enough that the brick does not fall out.

The net force on the brick as it is swung has maximum magnitude at position.
A) Top.  
B) Bottom.  
C) Right  
D) The net force has the same magnitude at all positions.

Answer: The net force has the same magnitude at all positions.  
Since the magnitude of the acceleration is constant \(a = \frac{v^2}{R}\), the net force must have constant magnitude \(F_{\text{net}} = ma\).

Consider the normal force exerted on the brick by the bucket when the bucket is at the three positions shown: R, T, B. The magnitude of the normal force is a **minimum** at position...

A) Top.  
B) Bottom.  
C) Right  
D) The normal force has the same magnitude at all positions.

Answer: At the top. Draw free-body diagrams and keep in mind the net force has the same magnitude at the top and the bottom.
CTNA-8. Consider the following two situations:
Situation I: A car on Earth rides over the top of a round hill, with radius of curvature $= 100$ m, at constant speed $v = 35$ mph.
Situation II: A monorail car in intergalactic space (no gravity) moves along a round monorail, with radius of curvature $= 100$ m, at constant speed $v = 35$ mph.

Which car experiences larger acceleration?

A) Earth car       B) Space car
C) Both cars have the same acceleration.

Answer: Both cars have the same acceleration. The presence of gravity doesn’t change the fact that the acceleration has magnitude $a = v^2/r$. 
CTNA-9.

A mass \( m \) is pulled along a rough table at constant velocity with an external force \( F_{\text{ext}} \) at some angle above the horizontal. The magnitudes of the forces on the free-body diagram have not been drawn carefully, but the directions of the forces are correct.

Which statement below must be true?

A) \( F_{\text{EXT}} > F_{\text{FRICT}} \), \( N > mg \).
B) \( F_{\text{EXT}} < F_{\text{FRICT}} \), \( N < mg \).
C) \( F_{\text{EXT}} > F_{\text{FRICT}} \), \( N < mg \).
D) \( F_{\text{EXT}} < F_{\text{FRICT}} \), \( N > mg \).
E) None of these.

Answer: \( F_{\text{EXT}} > F_{\text{FRICT}} \), \( N < mg \)

What is the correct \( y \)-equation (given the choice of axes shown)?

A) \(+N - mg \sin \theta = ma\)  
B) \(+N - F_{\text{ext}} \sin \theta - mg = 0\)
C) \(+N - mg + F_{\text{ext}} \sin \theta = 0\)  
D) \(+N - mg + F_{\text{ext}} \cos \theta = 0\)

Answer: \(+N - mg + F_{\text{ext}} \sin \theta = 0\)
CTNA-10. A mass $m$ is pulled along a frictionless table with a constant external force $F_{\text{ext}}$ at some angle above the horizontal. The magnitudes of the forces on the free-body diagram have not been drawn carefully, but the directions of the forces are correct.

The magnitude of the net force on the block is

A) $N + F_{\text{ext}} + mg$
B) $N + F_{\text{ext}} \sin \theta - mg$
C) $N + F_{\text{ext}} \cos \theta - mg$
D) $F_{\text{ext}} \cos \theta$
E) None of these.

Answer: $F_{\text{ext}} \cos \theta$

What is the correct y-equation (given the choice of axes shown)?

A) $N - mg \sin \theta = ma$  
B) $N - F_{\text{ext}} \sin \theta - mg = 0$
C) $N - mg + F_{\text{ext}} \sin \theta = 0$
D) $N - mg + F_{\text{ext}} \cos \theta = 0$

Answer: $N - mg + F_{\text{ext}} \sin \theta = 0$
CTNA-11. A mass slides down a rough inclined plane with some non-zero acceleration $a_1$. The same mass is shoved up the same incline with a large, brief initial push. As the mass moves up the incline, its acceleration is $a_2$. How do $a_1$ and $a_2$ compare?

A) $a_1 > a_2$  
B) $a_1 = a_2$  
C) $a_1 < a_2$

Answer: $a_1 < a_2$  
Draw free-body diagrams! When the velocity is uphill, the direction of the force of friction is downhill.
CTNA-12.
A block of mass $m$ on a rough table is pulled by a string as shown. The string exerts a horizontal force of magnitude $F_T$. The coefficient of static friction between block and table is $\mu_S$; the kinetic friction coefficient is $\mu_K$. As always, $\mu_S > \mu_K$.

True (A) or False (B))
If the block does not move, it must be true that the force of friction is $F_{\text{fric}} = \mu_S N$.
Answer: False. The magnitude of the force of static friction can be anything between 0 and the max value of $\mu_S N$.

True (A) or False (B))
If the block does not move, it must be true that the string tension $F_T \leq \mu_S N$.
Answer: True.

True (A) or False (B))
If $F_T > \mu_K N$, the block must be accelerating.
Answer: False. The block might be at rest if $\mu_K N < F_T < \mu_S N$.

True (A) or False (B))
If $F_T > \mu_K N$, the block might be accelerating.
Answer: True.

True (A) or False (B))
If $F_T > \mu_S N$, the block must be accelerating.
Answer: True.
CTNA-13. A car rounds a banked curve at some speed without skidding. The radius of curvature of the curve is R. A possible free-body diagram (which may or may not be correct) is shown.

What can you say about $F_{\text{fric}}$, the magnitude of the force of friction?

A) $F_{\text{fric}} = \mu_s N$  
B) $F_{\text{fric}} = \mu_k N$  
C) Neither.

Answer: Neither! The car is not skidding, so this must be static friction, not kinetic friction. But static friction can have any magnitude between zero and the max value of $\mu_k N$.

What can you say about the direction of $F_{\text{fric}}$?

A) It is in the direction shown in the free-body diagram.  
B) It is in the direction opposite shown in the diagram.  
C) The direction depends on the speed of the car.

Answer: The direction depends on the speed of the car. If the car is going too slow, it will tend to slide down the incline (and the direction of the force of friction is then up the incline). If the car is going too fast, it will tend to slide up the incline (and the direction of the force of friction is then down the incline).
CTNA-14.
A person holds a block against a vertical wall with force $F$ at a known angle $\theta$. (The block has weight $mg$, the coefficient of static friction is $\mu_s$.) What is the direction of the force of friction on the book from the wall?

A) up  
B) down  
C) no direction, the frictional force is zero  
D) impossible to tell from the information given

Answer: Impossible to tell from the info given. You might be pushing so hard that the book is just about to slip upward, in which case the force of static friction is down. Or you might be pushing barely hard enough to prevent the block from slipping downward, in which case the force of friction is upward. In you push with just the right sized force, the force of friction is zero. You cannot tell from the info given.
CTNA-15.
A person holds a block against a vertical wall with force $F$ at a known angle $\theta$. (The block has weight $mg$, the coefficient of static friction is $\mu_s$.) What is the magnitude of the force of static friction on the book from the wall?

A) $f = \mu_s mg$

B) $f = \mu_s |F_x|$

C) $f = 0$

D) None of these.

Answer: none of these. See the previous question’s answer. You do not know the size of the force of static friction, nor do you know its direction.