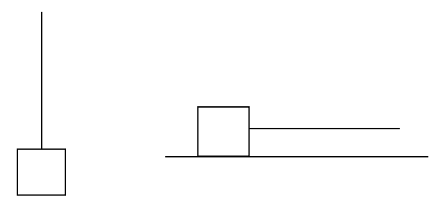
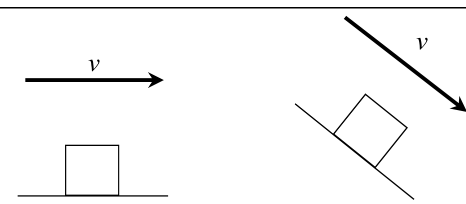
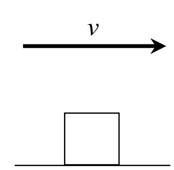
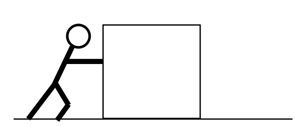
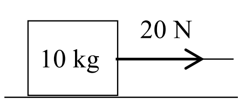
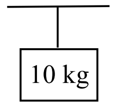
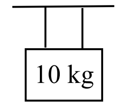
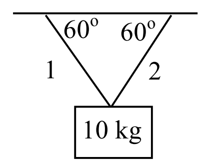
Assignment 11	NEWTON'S LAWS		
1. Force			
2. Object			
3. Agent			
4. Contact force			
5. Long range force			
6. Common forces	Define	Variable	Vector diagram
(A) Weight			
(B) Tension			
(C) Normal force			
(D) Friction			
(E) Drag (air resistance)			
(F) Applied Force			

7. Free Body Diagram (FBD). A simple diagram showing all the force vectors acting on an object.	(A) A sled pulled horizontally along a rough surface by rope inclined at an angle of 30^o. Air resistance is negligible.	(B) A block of wood sliding down a rough incline.
8. Objects and systems		
9. Distinguish between external and internal forces		
10. Net force		
11. Mass		
12. Newton's first law of motion		
13. Newton's second law of motion (A) Statement of the law in words (B) Expressed as an equation	(A)	(B)
14. Newton's third law of motion (A) Statement of the law in words (B) How can the weight of a person relative to Earth be the same as the weight of Earth relative to a person? After all the Earth is so much larger.		

<table>
<tr><th>Assignment 12</th><th colspan="2">EQUILIBRIUM</th></tr>
<tr><td rowspan="5">15. Equilibrium
(A) Define
(B) How are forces arrranged in equilibrium?
(C) Net force in equilibrium?
(D) Which of Newton’s laws applies in equilibirum?
(E) Effect on the motion of objects?</td><td colspan="2">(A)</td></tr>
<tr><td colspan="2">(B)</td></tr>
<tr><td colspan="2">(C)</td></tr>
<tr><td colspan="2">(D)</td></tr>
<tr><td colspan="2">(E)</td></tr>
<tr><td>16. Distinguish between static and dynamic equilibrium</td><td>Static equilibrium</td><td>Dynamic Equilibrium</td></tr>
<tr><td rowspan="4">17. Technique for solving force problems

A 10 kg mass is pulled along a rough surface at <u>constant velocity</u> by a rope exerting 20 N of force.
(A) Determine the force of friction acting on the mass.
(B) Determine the normal force acting on the mass.</td><td colspan="2">Assess: Which direction is relevant? Is the sum of forces equal to zero, or will have a value?</td></tr>
<tr><td colspan="2">Diagram: Draw a formal free body diagram and/or a diagram of relevant forces and components.</td></tr>
<tr><td colspan="2">Sum of force: Write the sum of force equation (or a balanced forces equation, if relevant)</td></tr>
<tr><td colspan="2">Solve: Substitute known equations and values, solving for the desired missing value(s).</td></tr>
</table>

18. Tension Problems	Determine the tension in the rope 	Determine the tension in each rope. 
Assess		
Diagram		
Sum of Force		
Solve		

19. A 10 kg mass is suspended by two ropes as shown in the diagram. Solve for the tension in each rope.



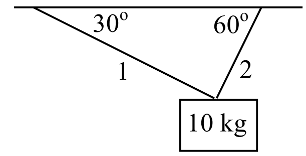
Assess:

Diagram:

Sum forces:

Solve:

20. A 10 kg mass is suspended by two ropes as shown in the diagram.



Assess:

Diagram:

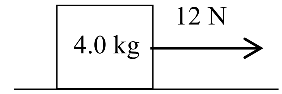
Sum forces:

Solve:

Assignment 13 SECOND LAW DYNAMICS

21. Unbalanced force problems (A) How are forces arrranged when unbalanced forces act? (B) Net force when unbalanced forces act? (C) Which of Newton's laws applies when unbalanced forces act? (D) Effect on the motion of objects?	(A) (B) (C) (D)

22. A 4.0 kg mass, initially at rest, is pushed by a 12 N force horizontally on a frictionless surface.



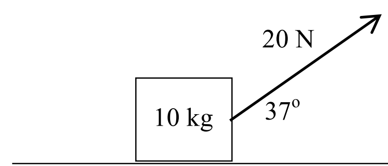
Assess:

Diagram:

Sum forces:

Solve:

23. A 10 kg mass, initially at rest, is pulled by rope with 20 N of tension directed 37°.



Assess:

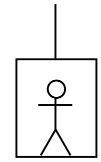
Diagram:

Sum forces:

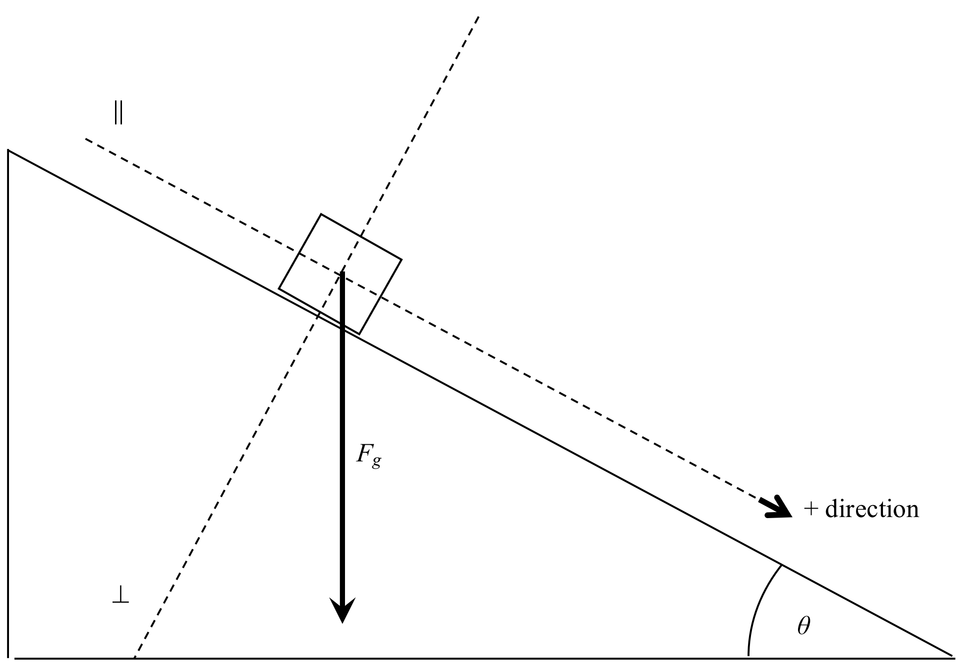
Solve:

Assignment 14	WEIGHT AND APPARENT WEIGHT	
24. Acceleration in g's. (A) What is a g of acceleration? (B) An object accelerates at 50 m/s^2. What is its acceleration in g's ? (C) An object accelerates at 2.5 g's. What is its acceleration in m/s^2 ?	(A) (B) (C)	
25. For the objects at the right determine	60 kg object	120 N object
(A) their mass on Earth.		
(B) their weight on Earth.		
(C) their mass on the Moon, where gravity is 1/6 of that on Earth.		
(D) their weight on the Moon, where gravity is 1/6 of that on Earth.		
26. Apparent weight (A) What is apparent weight? (B) How do humans feel weight? (C) What causes humans to feel an apparent weight that differs from actual weight? (D) When asked in a problem to solve for apparent weight which variable should you solve for? (E) What common household device can be used to measure apparent weight?	(A) (B) (C) (D) (E)	

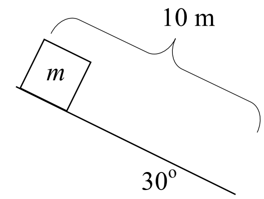
27. A 50 kg person rides in an elevator from the 1st to the 10th floor and back down to the 1st floor. When initially leaving the first floor the elevator accelerates upward at 2.0 m/s^2 until it reaches a speed of 3.0 m/s. It continues upward at a constant speed of 3.0 m/s until nearing the 10th floor. It then slows to a stop with a deceleration of 2.0 m/s^2. It remains at the 10th floor for a moment. Then the elevator accelerates downward at 2.0 m/s^2 until it reaches a speed of 3.0 m/s. It continues downward at a constant speed of 3.0 m/s. Finally it slows to a stop with a deceleration of 2.0 m/s^2.



Moving Upward	(A) leaves 1st floor initially accelerates up at 2.0 m/s^2.	(B) is moving upward at a constant velocity of 3.0 m/s.	(C) nearing 10th floor and decelerating at 2.0 m/s^2.	(D) is stopped at 10th floor.
Assess	Accelerating, up	Constant velocity, up	Decelerating, up	Stationary
Diagram				
Sum forces				
Solve				
Moving Downward	(A) leaves 10th floor initially accelerates down at 2.0 m/s^2.	(B) is moving down at a constant velocity of 3.0 m/s.	(C) nearing 1st floor and decelerating at 2.0 m/s^2.	(D) is stopped at 1st floor.
Assess	Accelerating, down	Constant velocity, down	Decelerating, down	Stationary
Diagram				
Sum forces				
Solve				

Assignment 15	**NORMAL FORCE AND INCLINES**		
28. What mechanism is responsible for the normal force?			
29. So far the normal force has been upward and vertical, as the surfaces have been horizontal and below the object. (A) Give an example of a downward normal force. (B) A horizontal normal force.	(A)	(B)	
30. A 10 kg mass is positioned on a horizontal surface (A) Draw the FBD and solve for the normal force. An applied force F_1 = 20 N pushes down on the mass. (B) Draw the FBD and solve for the normal force. An applied force F_2 = 50 N pulls up on the mass. (C) Draw the FBD and solve for the normal force.	(A)	(B)	(C)
31. A mass placed on a frictionless incline will slide parallel to the slope. (A) On the diagram at the right, split force gravity into components that are parallel and perpendicular to the slope. (B) Determine the component of gravity parallel to the slope. $\Sigma F_{g\parallel}$ = (C) Determine the normal force. $N_{incline}$ =	(A) 		

32. A 5.0 kg mass that is released from rest on a frictionless 10 m long 30° incline.

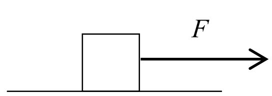
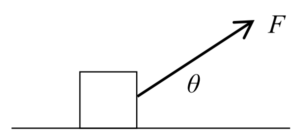
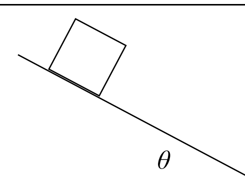
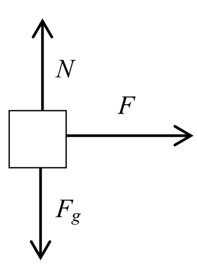
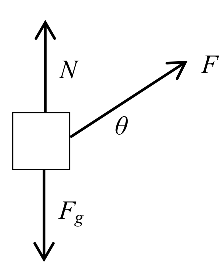
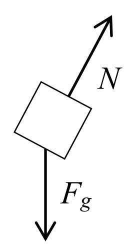


Assess:

Diagram:

Sum forces:

Solve:

33. **Normal Force**: Tricks student throughout the year. They wrongly think there is only one formula for the normal force. You must solve for the normal force in every problem. There are three scenarios that you will encounter frequently, and you may memorize the normal force for these common situations. However, **when you memorize shortcuts you must use them correctly.**			
			
	$N = F_g$ $N = mg$	$N + F_y = F_g$ $N = F_g - F_y$ $N = mg - F\sin\theta$	$N = F_g\cos\theta$ $N = mg\cos\theta$
	Additional forces parallel to the surface do not affect the normal force. However, any additional forces perpendicular, or at an angle to the surface will affect the normal force.		

Assignment 16 FRICTION AND DRAG

29. Visualizing friction

<table>
<tr><td rowspan="6">30. Friction
Force due to the roughness of surfaces. Always slows motion and is negative. There must be a forward force trying to move the object to have friction. The relationship between the forward force and friction is complicated.</td><td rowspan="6">$\boxed{f \le \mu N}$
Stationary Objects
$f < \mu N$
Moving Objects (including an object that is stationary, but will move in the next instant)
$f = \mu N$</td><td rowspan="3">f</td><td rowspan="3">Force of Friction</td><td rowspan="3">N</td><td>+</td><td>Never Positive</td></tr>
<tr><td>0</td><td>Frictionless surface (default: assume unless rough or friction)</td></tr>
<tr><td>–</td><td>If friction is present (moving or stationary)</td></tr>
<tr><td>μ_S</td><td>Coefficient of Static Friction</td><td>No units</td><td>+</td><td>Always</td></tr>
<tr><td>μ_K</td><td>Coefficient of Kinetic Friction</td><td>No units</td><td>+</td><td>Always</td></tr>
<tr><td>N</td><td>Normal Force</td><td>N</td><td>+</td><td>If touching a surface</td></tr>
</table>

31. There are two coefficients of friction. (A) When is μ_s used? (B) When is μ_k used? (C) Which type of friction is stronger?	(A) (B) (C)
32. Factors affecting friction: Variable and how it affects friction. (A) Surfaces? (B) Object? (C) Area?	(A) (B) (C)
33. How does doubling the (A) mass affect the magnitude of the friction force? (B) Surface area affect the magnitude of the friction force?	(A) (B)

34. A 2.0 kg block is initially at rest on a rough horizontal surface with coefficients of friction $\mu_s = 0.2$ and $\mu_k = 0.1$.

Static friction varies as horizontal force is applied to a mass, and it has a maximum value.

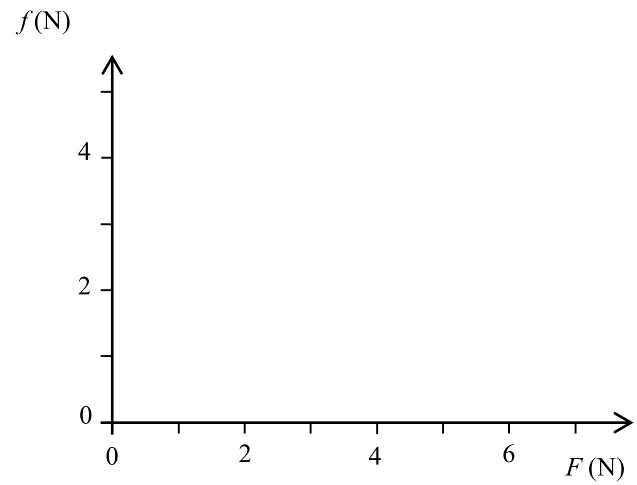
(A) Calculate max static friciton, draw it as a dashed line on the graph, and label the line as $f_{s\ max}$.

$$f_{s\ max} = \mu_s N = \mu_s mg =$$

We will apply a changing horizontal force F to the mass and examine the resulting affect on the friction force f.

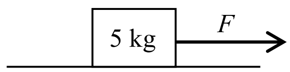
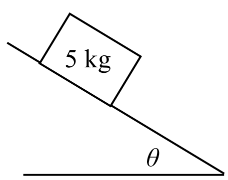
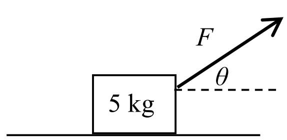
(B) Determine friciton force. Draw and label it in the diagrams below. Plot it on the graph at the right
(C) Compare f and F (equal, greater, less, etc.)
(D) How does the formula compare to f determined?
(E) Resulting motion.

(B)



Depiction of forward force F	C) How f and F compare?	D) How formula compares	E Resulting Motion
$F = 0$			
$F = 1$			
$F = 2$			
$F = 3$			
$F = 4$			
$F = 4.00000…01$			
$F = 5$			
$F = 6$			
To maintain constant velocity, F = ? $F =$			

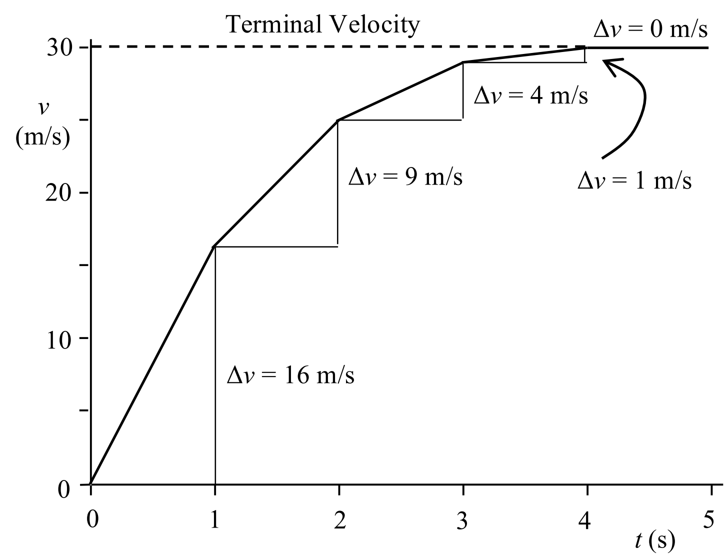
When an object is stationary ($v = 0$)		
About to move or just barely moves ($v = 0$)		
Constant velocity		
Accelerating		

35. A 5.0 kg box is pulled at constant velocity by a 10 N force along a rough surface. Complete all five steps to find the coefficient of friction. 	
36. Complete all five steps to determine the acceleration of a mass on a 30° incline that has coefficients of friction, $\mu_s = 0.2$, and $\mu_k = 0.1$. 	
37. A 5.0 kg box is pulled along a surface ($\mu_k = 0.1$) by a 10 N force at an angle of 37°. Complete all five steps to determine the acceleration. 	

38. Drag (A) What causes drag? (B) Drag can be thought of as… (C) The drag vector is always directed ____ motion. (D) The drag vector depends on what three things?	(A) (B) (C) (D)		

39. Drag due to the air on Earth is nearly $D_{air} \approx \frac{1}{4} A v^2$

This formula is a reasonable approximation for objects with a surface area A from the size of a marble up to that of the front of a large truck. It works for speeds up to those of jet airplanes. AP Physics B does not need to memorize it and so far it has not showed up on an AP Phyiscs exam without being given (Usually as follows: "The force of air resistance is $F_D = bv^2$, where b is a constant."). While memorizing it may not be important it is not a bad idea to realize that air reistance is roughly proportional to the square of velocity. The mathematics of air resistance requires integral calculus, as the graph at the right should really be a smooth curve. However, without Calculus we can look at each one second interval as though it is linear. This is not accurate but, it does help to gain a conceptual understanding.



40. The object graphed above is a 1.0 kg mass with a surface area $A = 1.0\ \text{m}^2$ running into air resistance. The mass accelerates from rest. We will exam each one second interval looking at
(A) The velocity at the end of each second.
(B) The change in velocity during that second.
(C) The average acceleration during that second (we are straightening the curve and can only calculate the ave. accel. without Calculus).
(D) The sum of forces that would create the average acceleration seen each second.

Time interval	v (m/s)	Δv (m/s)	$a_{ave} = \frac{\Delta v}{t} = \frac{\Delta v}{1}$	$\Sigma F = ma = (1)a$
1st second				
2nd second				
3rd second				
4th second				
5th second				

41. The graph and table above show the effect of air resistance when a constant forward force (engine for a car, gravity for a sky diver) is applied to an object initially at rest. State the resulting trend for the following variables during its motion.
(A) Drag force (force of air resistance)
(B) Sum of forces
(C) Acceleration
(D) Velocity

(A) During the resuling motion the drag force…

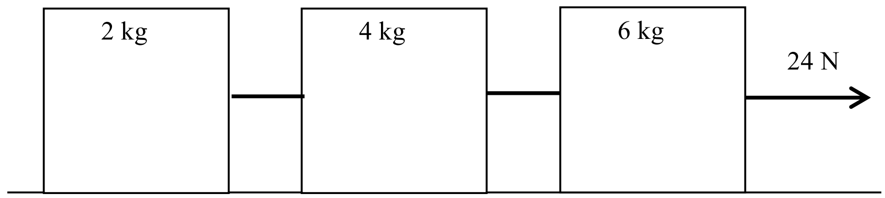
(B) During the resuling motion the sum of force…

(C) During the resuling motion the acceleration…

(D) During the resuling motion the velocity…

Assignment 17	COMPOUND BODIES
42. **Compound body**	

43. Three blocks $m_1 = 2$ kg $m_2 = 4$ kg, and $m_3 = 6$ kg are pulled by a string with tension $T = 24$ N, as shown below.



(A) Acceleration of the system.

(B) Net force on m_1.

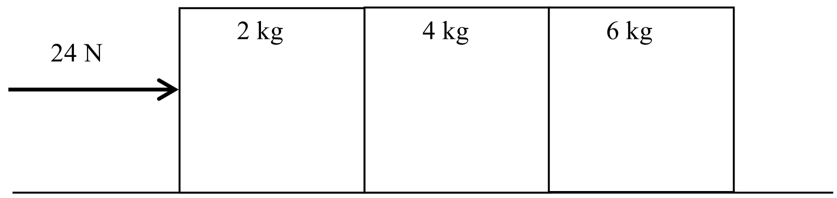
(C) Net force on m_2.

(D) Net force on m_3.

(E) Tension in the string between m_1 and m_2

(F) Tension in the string between m_2 and m_3

44. Three blocks $m_1 = 2$ kg $m_2 = 4$ kg, and $m_3 = 6$ kg are acted upon by a force $F = 24$ N, as shown in the diagram below.



(A) Acceleration of the system.

(B) Net force on m_1.

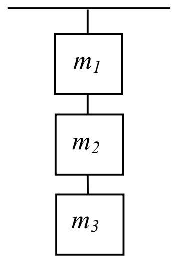
(C) Net force on m_2.

(D) Net force on m_3.

(E) Force between m_1 and m_2

(F) Force between m_2 and m_3

45. Three blocks $m_1 = 2$ kg $m_2 = 4$ kg, and $m_3 = 6$ kg are suspended from strings as shown. Determine each of the following quantities.



   (A) Acceleration of the system.
   (B) Net force on m_1
   (C) Net force on m_2
   (D) Net force on m_3
   (E) Tension between ceiling and m_1
   (F) Tension between m_1 and m_2
   (G) Tension between m_2 and m_3

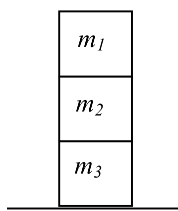
(A)	(B)	(C)	(D)

(E)

(F)

(G)

46. Three blocks $m_1 = 2$ kg $m_2 = 4$ kg, and $m_3 = 6$ kg are stacked as shown. Determine each of the following quantities.



   (A) Acceleration of the system
   (B) Net force on m_1
   (C) Net force on m_2
   (D) Net force on m_3
   (E) Force between m_1 and m_2
   (F) Force between m_2 and m_3
   (G) Force between m_3 and the floor

(A)	(B)	(C)	(D)

(E)

(F)

(G)

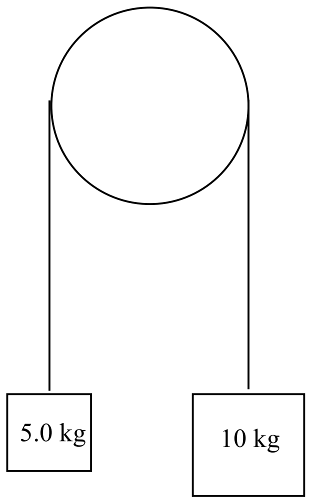
Assignment 18 PULLEYS

47. What is the effect of **MASSLESS** pulleys on
   (A) the magnitude of forces in the problem?
   (B) the direction of forces in the problem?

A)

B)

48. Mass $m_1 = 5.00$ kg is connnected to mass $m_2 = 10.0$ kg by a string drapped over a massless frictionless pulley, as shown in the diagram. The masses are released from rest.



(A) What is this device called?

(B) Assess

(C) Diagram

(D) Sum of forces and solve for acceleration.

(E) Sum of forces and solve for tension.

(A)

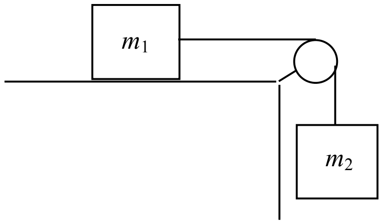
(B) Assess

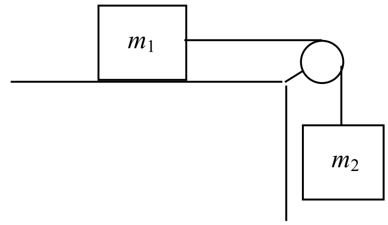
(C) Diagram

(D) Sum of forces and solve for acceleration.

(E) Sum of forces and solve for tension.

49. Mass m_1 is on a horizontal surface is connnected to mass m_2 by a string drapped over a massless frictionless pulley, as shown in the diagram. The masses are released from rest.





<table>
<tr><th>FRICTIONLESS</th><th>FRICTION</th></tr>
<tr><td>(A) FBD

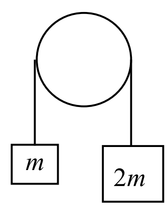
</td><td>(A) FBD

</td></tr>
<tr><td>(B) Sum of forces equation</td><td>(B) Sum of forces equation</td></tr>
<tr><td rowspan="3">(C) Substitute known equations</td><td>(C) Substitute known equations if masses remain stationary</td></tr>
<tr><td>(C) Substitute known equations if constant velocity results</td></tr>
<tr><td>(C) Substitute known equations if masses accelerate</td></tr>
<tr><td rowspan="3">(E) List an equation to find tension in the string</td><td>(E) List an equation to solve for tension if stationary</td></tr>
<tr><td>(E) List an equation to solve for tension if constant velocity</td></tr>
<tr><td>(E) List an equation to solve for tension if accelerating</td></tr>
</table>

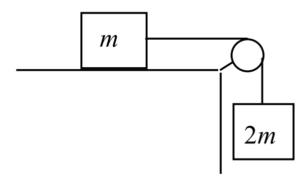
50.	**Numerical Problems**	**Variable Problems**
Givens	Actual values with units: $\boldsymbol{m_1 = 1}$ **kg and** $\boldsymbol{m_2 = 2}$ **kg.**	Variables only (no units): **Masses** $\boldsymbol{m}$ **and** $\boldsymbol{2m}$ **.**
How solved	Easy: Substitute the numbers and calculate.	Tells us the relative sizes of the masses compared to each other. $2m$ has twice the mass of m . Substitute the letters and coefficients. Solve algebraically.
Constants	Need numbers: $g = 9.8$ and $\pi = 3.14$	**Stay with letters:** $\boldsymbol{g = g}$ **and** $\boldsymbol{\pi = \pi}$ The only numbers allowed are coefficients.
Units	Units in calculations are optional. However, including units helps and canceling them, ensure the correctness of the answer. It does create more clutter and uses time.	**No units** Unit letters can become confused with variable letters.
Answer	If given numbers and units, then answer with **numbers and units**.	If given variables and coeffiients (with no units), then answer with **variable and coefficient** (with **no units**).

51. For the two problems below the masses are m and $2m$. Determine acceleration and tension.

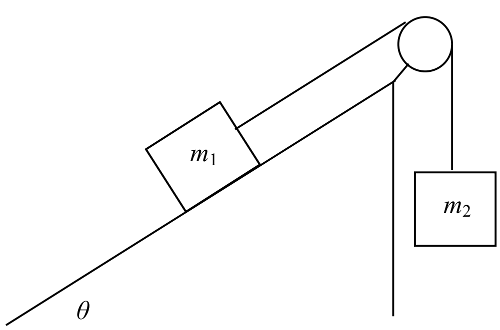
(A)



(B) Frictionless



52. For this example $m_1 = m_2$.



(A) Sum forces to find acceleration if the incline is frictionless.
(B) Sum forces to find acceleration if the incline has friction.
(C) Sum forces to find friction that will keeep system stationary.
(D) Sum forces for one mass only to find tension.

Note: If the hanging mass is equal or larger than the inclined mass, the motion will be towards the hanging mass. When the hanging mass is smaller you may have to solve $F_g = mg$ for the hanging mass and $F_g = mg\sin\theta$ for the inclined mass to determine which force is larger.

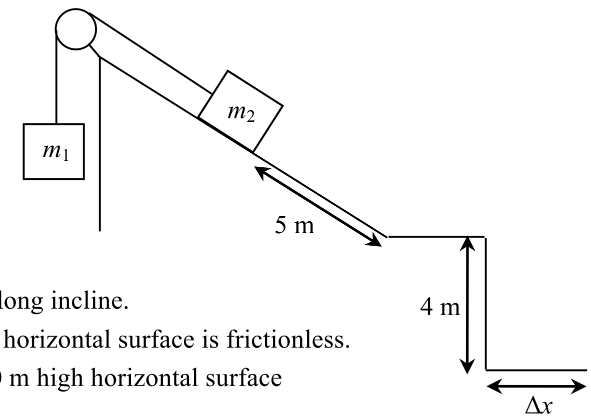
(A) Find acceleration if frictionless.

(B) Find acceleration if friction.

(C) Find friction to keep stationary.

(D) Find tension

53. Mass $m_2 = 20$ kg is located on a rough incline, $\mu_s = 0.3$, $\mu_k = 0.2$, and $\theta = 37^o$. It is connnected to mass m_1 by a string drapped over a massless frictionless pulley, as shown in the diagram at the right.



(A) Draw the FBD for each mass.

(B) Determine the largest possible m_1 that allows the system to remain stationary.

(C) Determine the tension in the string.

The string is now cut.

(D) Determine the speed of m_2 when it reaches the bottom of the 5.0 m long incline.

(E) Assume the mass transitions to the flat surface smoothly and that the horizontal surface is frictionless.

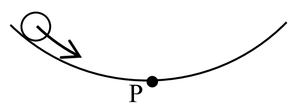
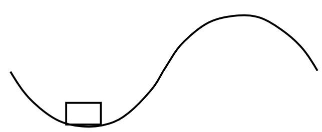
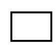
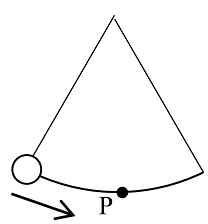
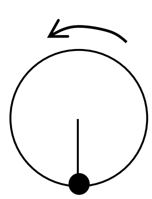
(F) Determine the horizontal range Δx of mass m_2 after leaving the 4.0 m high horizontal surface and impacting the ground below.

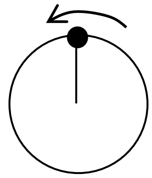
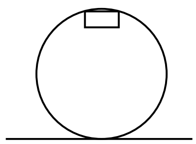
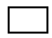
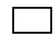
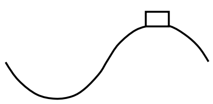
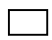
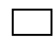
54. **Simple Machines**: Lever, Pulley, Incline	Create **Mechanical Advantage**: Require less force to accomplish a task, but objects must travel greater distances using longer time.

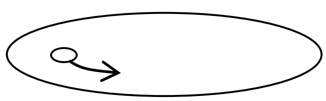
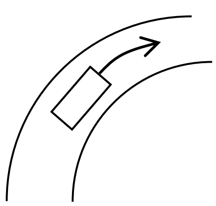
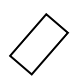
Assignment 19 CIRCULAR MOTION, PART 1

55. When writing the sum of force equation, (A) What takes the place of ΣF ? (B) How are the signs on acting forces assigned?	(A)
	(B)

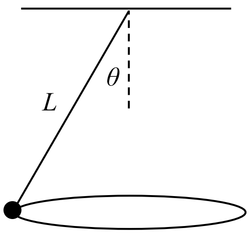
For the following problems draw the FBD in part (a) and write the sum of force equation in (b).

56. Lowest point in circles	Diagram	FBD	Sum Forces
(A) A ball rolls through a circular arc as shown. Solve when it is at point P.			
(B) A roller coaster is in the two positions shown.			
(C) A pendulum swings through its arc. Solve when mass is at point P.			
(D) A mass is spun through the air in a vertical circle by a string.			

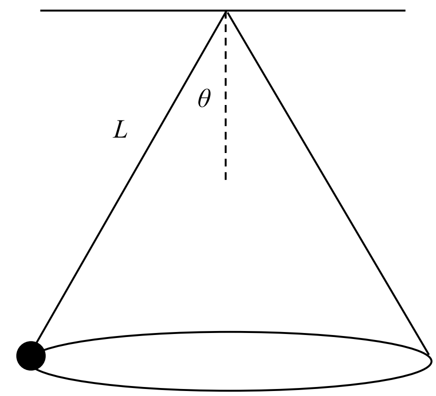
57. Highest point in circles: Two solutions		No specific information given		Minimum Speed or Weightless	
(A) A mass is spun through the air in a vertical circle by a string.					
(B) A roller coaster is in the position shown.					
(C) A roller coaster is in the position shown.					

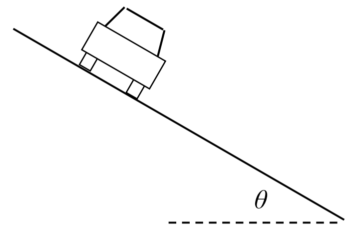
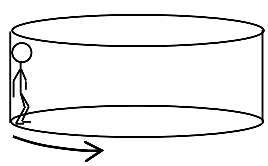
58. Friction	If an object is circling with nothing holding it in place, then friction may be acting toward the center.		
(A) A penny on a turn table, or a child on a merry-go-round.			
(B) Car making a turn. Solve at the instant pictured (from above) at the right.			
(C) Which coefficient of friction is needed, and how does this affect the problem parameters?			

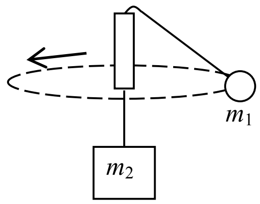
Assignment 20 CIRCULAR MOTION, PART 2



59. A mass $m = 200$ g is attached to one end of a string of length $L = 50$ cm. The other end of the string is tied to a fixed point on the ceiling. The apparatus is set into motion so that the mass moves in a circular path and the string traces out a cone, $\theta = 37^{o}$.
    (A) Assess
    (B) FBD and vector component diagram
    (C) Determine the radius of the circle. We may need this later.
    (D) Sum of forces
    (E) Solve for the tangential velocity
    (F) Determine the period of motion experienced by the mass.

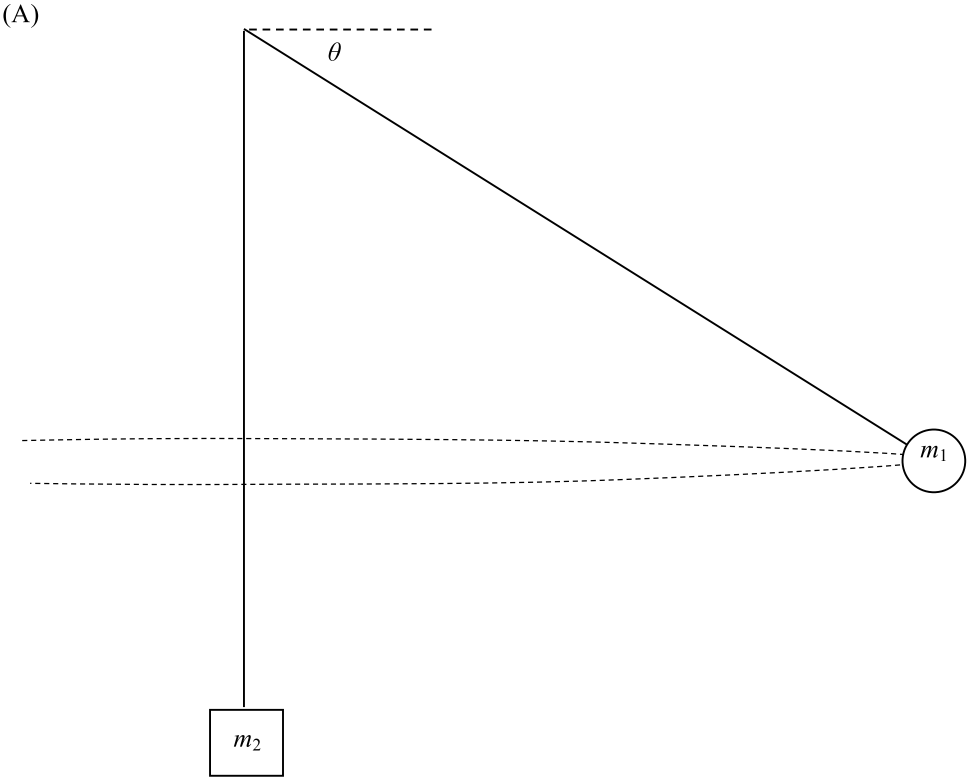
***y*-direction**	***x*-direction (*x*-*z* plane)**
(A) Assess	Assess
(B) FBD 	Vector component diagram 
(C) Radius	
(D) Sum of force	Sum of force
(E) Solve for tangential velocity	
(F) Solve for the period of the motion	

<table>
<tr><td rowspan="5">60. A 1000 kg car is half way through a banked turn with a radius of 20 m and an incline of 37°.
(A) Assess
(B) Diagram
(C) Sum of forces
(D) Solve</td><td>y-direction</td><td>x-direction (x-z plane)</td></tr>
<tr><td>(A) Assess</td><td>Assess</td></tr>
<tr><td>(B) FBD Diagram</td><td>Diagram with components
</td></tr>
<tr><td>(C) Sum of forces</td><td>Sum of forces</td></tr>
<tr><td colspan="2">(D) Solve</td></tr>
<tr><td rowspan="2">61. In an amusement park ride the room spins so fast that occupants feel pressed against the walls. The floor drops, but occupants do not slide down the wall.
(A) Complete the FBD for the rider in the position shown in the diagram.
(B) If the radius is 10 m and the coefficient of friction is 0.4 determine the minimum speed that the ride must turn in order to keep the occupants from sliding down the wall.</td><td></td><td>(A)
</td></tr>
<tr><td colspan="2">(B)</td></tr>
</table>



62. Another type of conical pendulum involves two masses. The masses are attached to each other by a string with length $L = 1.0$ m, that passes through a tube. Mass $m_1 = 3.0$ kg is spun in a circle at sufficient speed to keep mass $m_2 = 5.0$ kg stationary.
    (A) Complete FBD's for each mass in the positions shown in the diagram above.
    (B) Lets enlarge the picture and add the force vectors to this diagram.
    (C) Determine T and T_y.
    (D) Determine θ (note this angle is measured differently than the previous conical pendulum) and the radius r of the motion experienced by mass 1.
    (E) Determine the tangential velocity of mass 1.

(A)



(C)

(D)

(E)