Inclined Plane Analysis

Read from **Lesson 3** of the **Vectors and Motion in Two-Dimensions** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/vectors/u3l3e.html

MOP Connection: Forces in Two Dimensions: sublevels 5 and 6

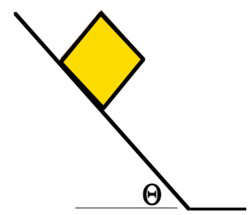
Review:

1. A normal force is a force that is always directed ________.
   a. upwards b. sideways c. perpendicular to the surface the object is touching

2. An object is upon a surface. The normal force is equal to the force of gravity ____.
   a. in all situations
   b. only when the object is at rest
   c. only when the object is accelerating
   d. only when there is no vertical acceleration
   e. only when there is no vertical acceleration AND F_{norm} and F_{grav} are the only vertical forces

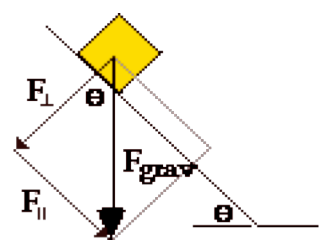
Getting the Forces Right:

3. The object at the right has been placed on a tilted surface or *inclined plane*. If there is enough tilt, it will accelerate from rest and begin its motion down the incline. Draw a free-body diagram for the object sliding down the *rough* incline. Label the three forces according to type (F_{grav}, F_{norm}, F_{frict}, F_{air}, F_{tens}, F_{app}, etc.).



Physics Tip: When you encounter a situation involving a force directed at angles to all other forces, immediately convert the *uncooperative* force(s) into two perpendicular components. Use SOH CAH TOA to resolve any uncooperative force into components directed at right angles to each other. One component should be in the direction of the acceleration; the other should be perpendicular to it. In the case of inclined planes, resolve the uncooperative force into components parallel and perpendicular to the inclined plane.

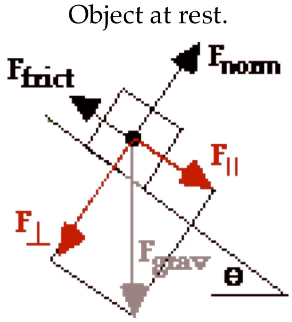
4. The force of gravity (or weight vector) is the *uncooperative force*. It is typically resolved into two components - one parallel to the plane and the other perpendicular to the plane. Given the diagram at the right with the two components of gravity represented as $F_{||}$ and $F_{\perp}$, use trigonometric functions to write equations relating these components to the force of gravity.



$F_{||}$ = ____________________ $F_{\perp}$ = ____________________

5. For the three situations described below, use <, > , or = symbols to complete the statements.

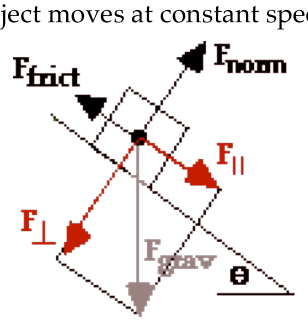
Object at rest.



$F_{||}$ ________ F_{frict}

$F_{\perp}$ ________ F_{norm}

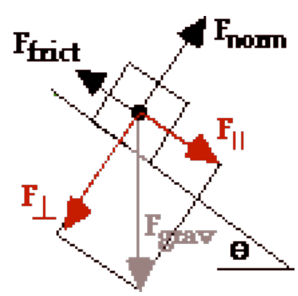
Object moves at constant speed.



$F_{||}$ ________ F_{frict}

$F_{\perp}$ ________ F_{norm}

Object accelerates down incline.

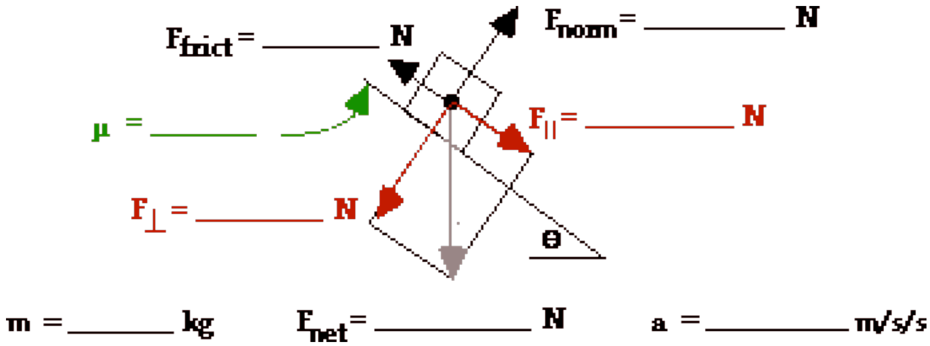


$F_{||}$ ________ F_{frict}

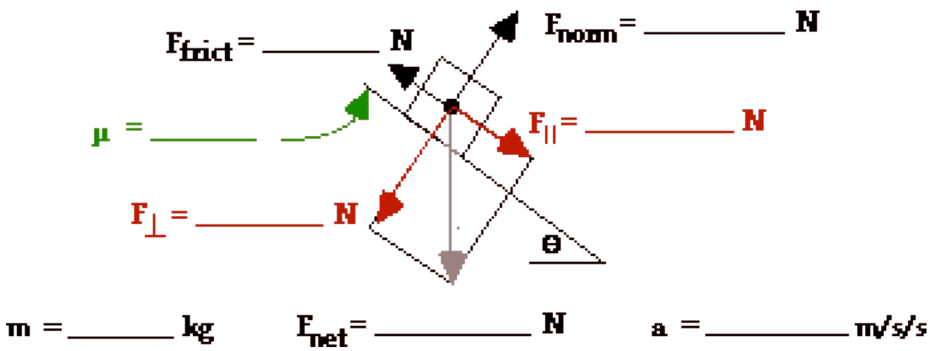
$F_{\perp}$ ________ F_{norm}

Use equations for calculating the components of gravity (#4) and Newton's laws to fill in the blanks.

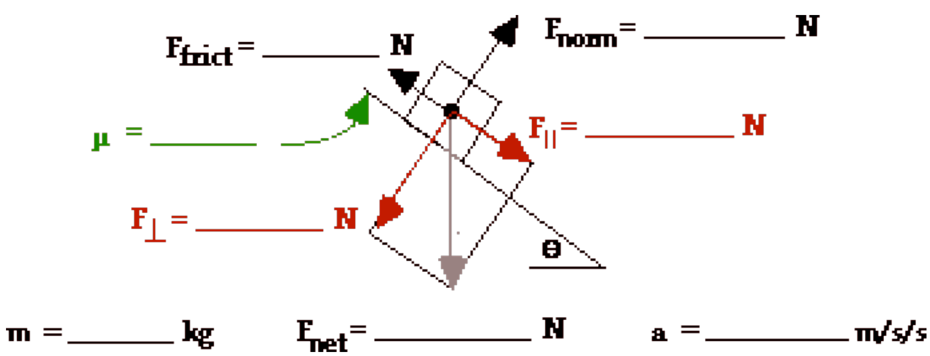
6. A 4.50-kg object is accelerating down an inclined plane inclined at 36.0° (with the horizontal) and having a coefficient of friction of 0.548.



7. A 65.0-kg crate remains at rest on an inclined plane that is inclined at 23.0° (with the horizontal).



8. A 41.3-kg box slides down an inclined plane (inclined at 29.1 degrees) at a constant speed of 2.1 m/s.



The Tilted Head Trick

Inclined plane problems can be easy. Resolve gravity into its components. Then, ignore the force of gravity. Finally, tilt the paper or your head and the problem becomes a simple $F_{net} = m \bullet a$ problem.