

# Advanced Placement Physics

# Force

**Force**

Any push or pull

**Newton's 1<sup>st</sup> Law**

Law of inertia (Restatement of Galileo's principle of inertia)

**Newton's 2<sup>nd</sup> Law**

$$\sum F = ma$$

**Newton's 3<sup>rd</sup> Law**

Equal and opposite forces. For every action force there is an equal & opposite reaction force. Forces come in action - reaction pairs.

$\sum F$  Key to all problems.  $\sum F_x$   $\sum F$  in  $x$  direction on traditional coordinate axis.  $\sum F_y$   $\sum F$  in  $y$  direction.  
 $\sum F_{\parallel}$   $\sum F$  parallel to a slope (direction of motion).  $\sum F_{\perp}$   $\sum F$  perpendicular to slope.

$\sum F = ma$  Sum of force is **Net Force**. You may need to solve for  $a$  using the kinematic equations, then solve for force, or given force you solve for  $a$  and then use it in the kinematic equations to find  $v$ ,  $x$ , or  $t$ .

## Strategy on force Problems:

1. Draw FBD.
2. Set direction of motion. *What would the object do if it could?* Considered this the positive direction.
3. Using the forces listed below write the  $\sum F$  equations relevant to the problem. *In what direction is the problem moving?* What matters, the  $x$  or the  $y$  direction? The *parallel* or the *perpendicular* direction? Any force vectors in the FBD pointing in the direction of motion are positive while any vectors the other way are negative.
4. Substitute known equation, (forces like  $F_g$  become  $mg$ ).
5. Substitute for  $\sum F$ . Ask yourself what the sum of force should be based on the chart below. Is the object standing still, moving at constant velocity, or accelerating. Substitute zero or  $ma$  for  $\sum F$ .

|   |                              |                                   |                            |               |
|---|------------------------------|-----------------------------------|----------------------------|---------------|
| 1 | $v = 0$                      | $\Delta v = 0$                    | $a = 0$                    | $\sum F = 0$  |
| 2 | $v = +/-$ a constant value   | $\Delta v = 0$                    | $a = 0$                    | $\sum F = 0$  |
| 3 | $v$ increasing or decreasing | $\Delta v = +/-$ a constant value | $a = +/-$ a constant value | $\sum F = ma$ |

6. Plug in and solve. (All values including 9.8 are entered as positives. The negative signs were decided when setting up the sum of force equation. Plugging in  $-9.8$  will just turn a vector assigned as  $-F_g$  into a positive. You decided its sign based on the way it was pointing relative to the problems direction of motion. Don't reverse it now!)

$F_p$  Push or Pull.

$F_g$  Force of gravity.  $F_g = mg$

$F_T$  Tension is a rope, string, etc. This force has no equation. You either solve for it, or it cancels, or it's given.

$F_N$  Force Normal. A contact force, always perpendicular to the surface. (On a tilted surface use  $\sum F_{\parallel}$  &  $\sum F_{\perp}$ )

$F_f$  Friction force.  $F_f = \mu F_N$  Always opposes motion. Static friction: not moving. Kinetic friction: object moving.

$F_{ar}$  Force of air resistance. This force has no equation. You either solve for it, or it cancels, or it's given.

$F_c$  Force Centripetal. It is the  $\sum F$  in circular motion problems. So  $F_c$  can be any force that keeps an object in circular motion.

$$F_c = F_g \quad F_c = F_N \quad F_c = F_T \quad F_c = F_p \quad F_c = F_f \quad \text{etc.}$$

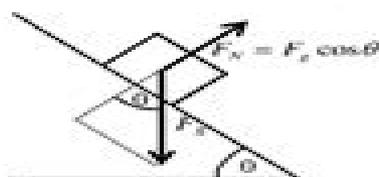
It can also be two or more of these added together. The direction of motion is toward the center. So any force directed toward the center is positive and any force directed outward is negative.

The key in using any of these equations is to ask yourself: 1. What is causing the circular motion? 2. Then set up the equality. 3. Substitute known equations. 4. Solve.

$F_B$  Force due to a magnetic field. This force is perpendicular to the field and perpendicular to the velocity of the particle. So any charged particle will move in a circle. Use the right hand rule for positive charges or positive current, and use the left hand for negative charges or electron current.

$F_{any}$  subscript that make sense to solve the problem

**Normal force:** Gravity pulls the object **down** the slope **and into the slope**. If we only consider the motion into the slope (perpendicular), the object has no perpendicular velocity. So the  $\sum F_{\perp} = 0$ . Then the surface must push upward, equal and opposite to the perpendicular gravity component. Named the normal force, it is a contact force and operates perpendicular to any surface. It must counter only the component of gravity perpendicular to the surface.



$F_N = F_g \cos \theta$  Where  $\theta$  is the angle between  $F_g$  and  $F_{g\perp}$ . It is also the tilt angle of the surface measured from the ground. Substituting  $mg$  for  $F_g$

$F_N = mg \cos \theta$  Flat surfaces  $\theta = 0^\circ$ .  $F_N = F_g$  or  $F_N = mg$

# Physics Forces Study Guide

**M Walker**



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