AP Physics 1 Dynamics Cheat Sheet

Newton's laws · free-body diagrams · inclines · friction · g = 9.8 m/s²

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NEWTON'S THREE LAWS

- **First:** if $\Sigma F = 0$, the velocity is constant, including zero.
- **Second:** $a = \Sigma F / m$, in the direction of the net force. Per axis: $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$.
- **Third:** $F_{A \text{ on } B} = -F_{B \text{ on } A}$. Same type of force, acting on different objects.
- Weight: $F_g = mg$, in newtons. Mass, in kilograms, is the same everywhere.

THE FORCES IN THIS UNIT

Force	Direction	Size
Gravity, F_g	Straight down	mg
Normal, F_N	Perpendicular to the surface, away from it	From $\Sigma F = ma$, not assumed
Tension, F_T	Along the string, away from the object	Same along an ideal string
Friction, F_f	Along the surface, against sliding	Up to $\mu_s F_N$, or $\mu_k F_N$ when sliding

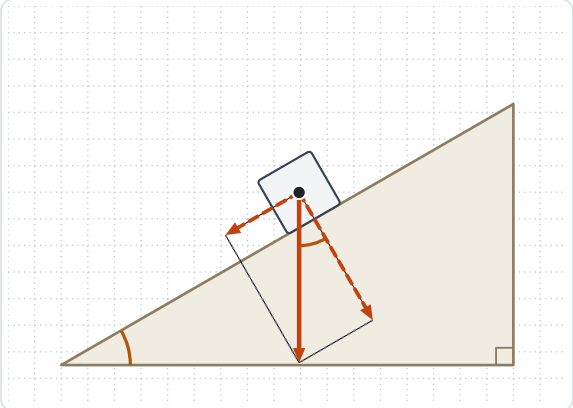
FREE-BODY DIAGRAM RULES

1. Draw one object as a dot.
2. Draw each force as one straight arrow from the dot, at full size.
3. Label the type and the source: F_N, table on block.
4. Leave off components, the net force, velocity, acceleration, and ma.
5. Pick axes with one axis along the acceleration.

FINDING THE NORMAL FORCE

Situation	F_N
Level surface, no other vertical force	mg
Pulled at θ above the horizontal	$mg - F \sin \theta$
Pushed at θ below the horizontal	$mg + F \sin \theta$
Incline at angle θ	$mg \cos \theta$
Elevator, up positive	$m(g + a)$

INCLINED PLANES



- Tilt the axes: x along the slope, y perpendicular to it.
- Along the slope: $mg \sin \theta$, downhill. Into the slope: $mg \cos \theta$.
- Frictionless: $a = g \sin \theta$ down the slope, and $F_N = mg \cos \theta$.
- Check at $\theta = 0$: the component of gravity along the slope must be zero, and F_N must equal mg. At $\theta = 90°$: $a = g$.

KEY

	Incline, tilted at angle θ above the horizontal
	Block, with a dot at its center
	Gravitational force, $F_g = mg$, straight down
	Components of F_g: $mg \sin \theta$ down the slope and $mg \cos \theta$ into the slope
	The incline angle θ, at the bottom corner and again between F_g and the perpendicular to the slope
	Guide lines: the two components add tip to tail to F_g

FRICTION

- Static: $F_f \le \mu_s F_N$. It takes whatever value keeps the surfaces from sliding.
- Kinetic: $F_f = \mu_k F_N$ while sliding. Usually $\mu_k < \mu_s$.
- On an incline, a block at rest starts to slide when $\tan \theta > \mu_s$. A block sliding downhill moves at constant velocity when $\tan \theta = \mu_k$.
- Sliding downhill: $a = g(\sin \theta - \mu_k \cos \theta)$, taking downhill as positive. A negative result means acceleration uphill.
- Sliding uphill: $a = g(\sin \theta + \mu_k \cos \theta)$, pointing downhill.
- Sliding on a level floor: $a = \mu_k g$, opposite the motion.

FIVE CHECKS BEFORE YOU HAND IT IN

1. Does every arrow name an object that exerts it?
2. Did I find F_N from the perpendicular equation instead of assuming mg?
3. Is static friction the value needed, and is it at most $\mu_s F_N$?
4. Does the component of gravity along the slope become zero at $\theta = 0$?
5. Does the acceleration point the same way as the net force?