AP Physics Review Sheet
Chapter 5: The Laws of Motion

Ellery Engstrom

Summary: Chapter 5 introduces Newton's Laws of Motion and explains how forces are related to motion. The chapter covers the three laws, different types of forces, and how to analyze motion using free-body diagrams and equations to solve problems of objects under forces.

Major Topics:	**Formulae:**
- Forces - Newton's 3 Laws - Mass and Weight - Drawing Free Body Diagrams - Inclined planes	- $\Sigma F = ma$ - $F_g = w = mg$ - $F_{\parallel} = mgsin\theta$ - $F_{\perp} = mgcos\theta$ - $F_{static} \leq \mu_s F_N$ - $F_{kinetic} = \mu_k F_N$

Key Vocabulary:

- Inertia - ability of an object to resist changes in its motion
- Force - push or pull on an object with a specific magnitude and direction
- Free-body diagram - sketch showing all external forces acting on a system
- Normal force - force supporting the weight of an object that is perpendicular to the surface of contact between the load and its support
- Tension - pulling force that acts along a stretched flexible connector, like a rope or cable
- Friction - a force that opposes the motion between two surfaces in contact

Newton's Three Laws:

- Newton's First Law (inertia) - a body at rest remains at rest or, if in motion, remains in motion at constant velocity unless acted on by a net external force
- Newton's Second Law (F = ma) - the net force acting on an object is equivalent to the mass of the object times its acceleration
- Newton's Third Law (equal and opposite reaction) - when one body exerts a force on a second body, the first body experiences a force equal in magnitude and opposite in direction to the force that it exerts

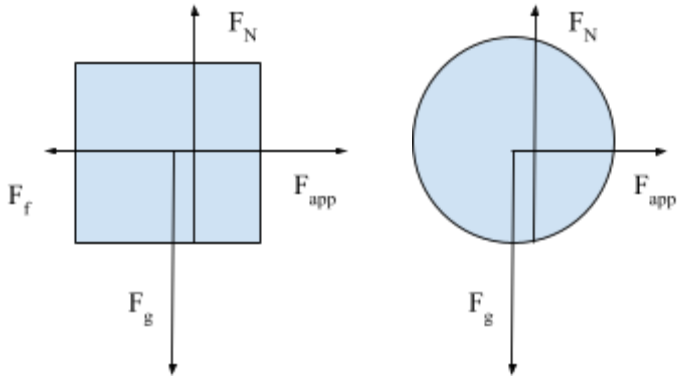
Mass vs. Weight

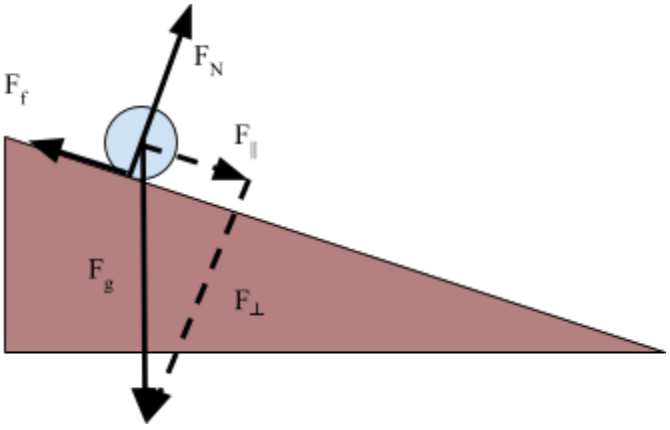
Mass is the amount of matter in an object. The mass of an object does not change with location.	Weight is the force of gravity acting on an object. The weight depends on the gravitational field strength.

Drawing Free Body Diagrams:

A free-body diagram shows all external forces acting on a single object

- Represent the object with a sketch (basic object like a square, circle, etc.)
- Draw arrows for each force, pointing in the direction of the force
  - Consider forces of gravity, normal, tension, friction…
- The arrow length should match the magnitude of the force relative to the other forces





Inclined Planes

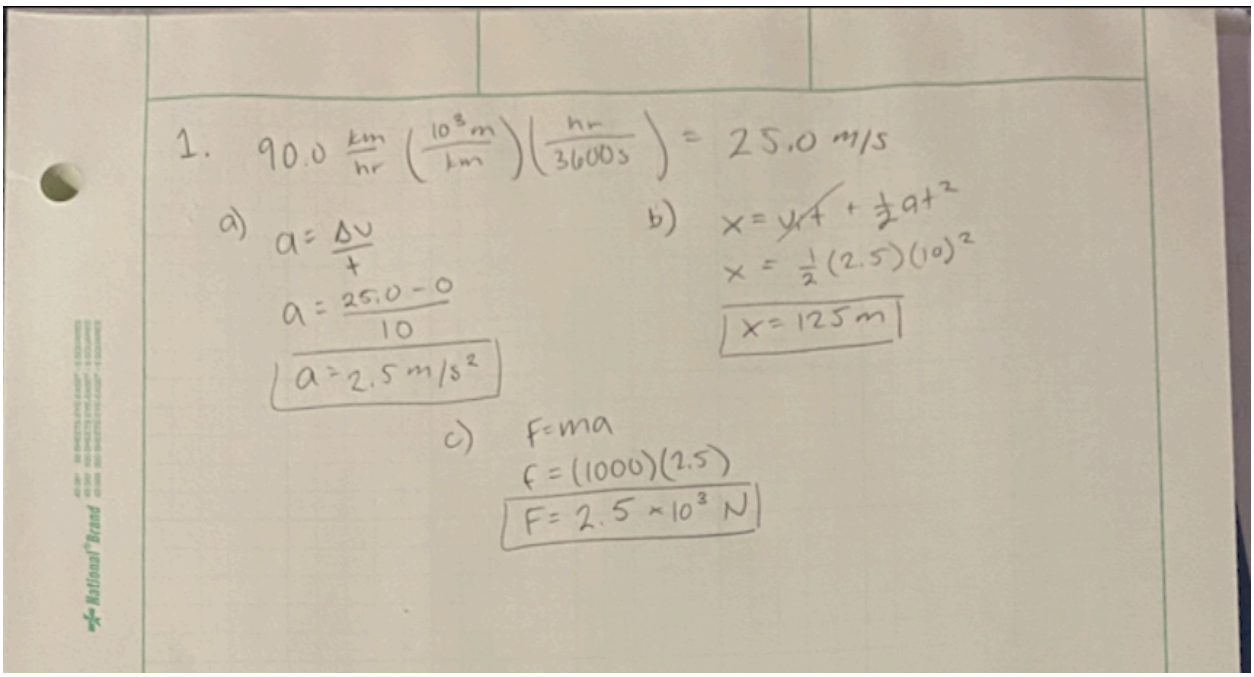
An inclined plane is a tilted surface where an object moves at an angle instead of straight up/down or left/right. Gravity still acts straight down, but the motion happens along the slope.

- Draw a free-body diagram
- Rotate axis to align with the incline
- Gravity is split into components
  - $F_{\parallel}$ is parallel to the surface and causes the motion
  - $F_{\perp}$ is the force perpendicular to the slope and balances the normal force

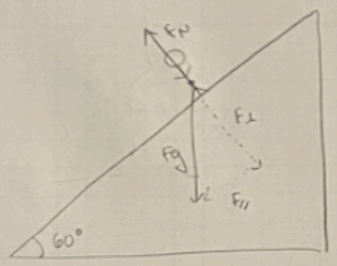
Questions:

1. A car with a mass of 1000.0 kg accelerates from 0 to 90.0 km/h in 10.0 s.
    a. What is its acceleration?
    b. How far does the car travel in the 10.0 s while it is accelerating?
    c. What is the net force on the car?
2. A skier, beginning from rest, descends a slope that is essentially frictionless and tilted at 60° below the horizontal.
    a. What is their acceleration?
    b. What is the skier's acceleration if the angle were smaller (ex. 30°)? Explain qualitatively.
3. A small spider of mass 2.00×10^{-5} kg hangs motionless from a strand of silk web. In one situation, the strand is vertical and supports the spider directly. In another situation, the spider sits at rest in the middle of a horizontal strand of web that sags symmetrically, with each side making an angle of 12° below the horizontal.
    a. What is the tension in the vertical strand?
    b. What is the tension in the horizontal strand?
    c. Compare the two tensions by finding their ratio $\frac{T_{horizontal}}{T_{vertical}}$

Answers:



2.



a) $f_{net-x} = ma_x$

$F_{\parallel} = ma_x$

$mg\sin\theta = ma_x$

$g\sin\theta = a_x$

$9.8\sin(60) = a_x$

$\boxed{8.5\ m/s^2 = a_x}$

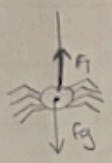
b) If the angle was smaller, the skier's acceleration will be smaller. This is because the component of gravity pulling the skier down the slope depends on the angle:

steeper slope = larger component of gravity → greater acceleration

smaller slope = smaller component of gravity → less acceleration

Mathematically: $\sin(30^\circ) < \sin(60^\circ)$, acceleration at 30° is less than at 60°

3. a)



$F_T = F_g$

$T = mg$

$T = (2.00\times10^{-5})(9.8)$

$\boxed{T = 1.96\times10^{-4}\ N}$

b)

$F_T = F_g$

$2T\sin(12)^\circ = mg$

$T = \dfrac{mg}{2\sin(12)}$

$T = \dfrac{(2.00\times10^{-5})(9.8)}{2\sin(12)}$

$\boxed{T = 4.71\times10^{-4}\ N}$

c) $\dfrac{T_{horizontal}}{T_{vertical}}$

$\dfrac{4.71\times10^{-4}}{1.96\times10^{-4}} = \boxed{2.4}$