

Newton's Law in Components

- Use Experimental Force Laws and Newton's Second Law to predict the acceleration of the body

$$F_x^{total} = ma_x$$

$$F_y^{total} = ma_y$$

$$F_z^{total} = ma_z$$

Methodology for Newton's Second Law

I. Understand – get a conceptual grasp of the problem

- Think about the problem.
- Sketch the system at some time when the system is in motion.
- Choose a coordinate system and identify the position function of all objects.
- Quantify the constraint conditions.
- Draw free body diagrams for each body in the problem.

II. Devise a Plan

Draw free body diagrams for each body in the problem.

- Include the set of unit vectors
- Each force represented by an arrow indicating the direction of the force
- Choose an appropriate symbol for the force

Choosing directions for the forces

- If you solve for a force and find that the force is negative then the force points in the opposite direction as your choice of direction for the force.

II. Devise a Plan - (con't)

Apply vector decomposition to each force in the free body diagram

$$\vec{\mathbf{F}}_i = (F_x)_i \hat{\mathbf{i}} + (F_y)_i \hat{\mathbf{j}} + (F_z)_i \hat{\mathbf{k}}$$

Apply superposition principle to find total force in each direction

$$\hat{\mathbf{i}} : F_x^{total} = (F_x)_1 + (F_x)_2 + \dots$$

$$\hat{\mathbf{j}} : F_y^{total} = (F_y)_1 + (F_y)_2 + \dots$$

$$\hat{\mathbf{k}} : F_z^{total} = (F_z)_1 + (F_z)_2 + \dots$$

II. Devise a Plan: Equations of Motion

- Application of Newton's Second Law

$$\vec{\mathbf{F}}^{total} = m\vec{\mathbf{a}}$$

- This is a vector equality so the two sides are equal in magnitude and direction

$$\hat{\mathbf{i}} : (F_x)_1 + (F_x)_2 + \dots = ma_x$$

$$\hat{\mathbf{j}} : (F_y)_1 + (F_y)_2 + \dots = ma_y$$

$$\hat{\mathbf{k}} : (F_z)_1 + (F_z)_2 + \dots = ma_z$$

II. Devise a Plan (con't)

Analyze whether you can solve the system of equations

- Common problems and missing conditions.
- Constraint conditions between the components of the acceleration.
- Action-reaction pairs.
- Different bodies are not distinguished

Design a strategy for solving the system of equations.

III. Carry Out your Plan

Hints:

Use all your equations. Avoid thinking that one equation alone will contain your answer!

After you solve your equations of motion for the components of acceleration, you now may consider whether your kinematic models will help you solve the problem.

IV. Look Back

- **Check your algebra**
- **Substitute in numbers**
- **Check your result**
- **Think about the result:** solved problems become models for thinking about new problems.