Newton's Law of Motion

Physics 211
Syracuse University, Physics 211 Spring 2015
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Forces

Rational mechanics must be the science of the motions which result from any forces, and of the forces which are required for any motions, accurately propounded and demonstrated. For many things induce me to suspect, that all natural phenomena may depend upon some forces by which the particles of bodies are either drawn towards each other, and cohere, or repel and recede from each other: and these forces being hitherto unknown, philosophers have pursued their researches in vain. And I hope that the principles expounded in this work will afford some light, either to this mode of philosophizing, or to some mode which is more true.

-Isaac Newton, *Philosophiae Naturalis Principia Mathematica* (1687), translated from the Latin by Whewell (1837)

Forces

*Mechanics involves figuring out how things move from knowing the forces that act on them, and figuring out what forces act on them if we know how they move. I suspect that all physical things involve things exerting forces on each other, and since we don't know what forces these are, nobody's been able to figure much out. Hopefully someone will read this book and figure this stuff out, either following my suspicion that it's all forces under the hood (***classical physics!***), or with some deeper understanding of nature (***quantum physics!***)*

-Isaac Newton, *Philosophiae Naturalis Principia Mathematica*, in modern English

Announcements

- Homework 3 due Friday
- Bring your computers/tablets to recitation tomorrow
- If you don't have one, check one out from the library
- Regrade requests due Friday

Force is a vector

$$\vec{F} = m\vec{a}$$

- Force is a *vector*
- Multiple forces on an object add like vectors do
- Really, we should write

$$\sum \vec{F} = m\vec{a}$$

Sample questions

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(Use $\vec{F} = m\vec{a}$ to connect force to acceleration, and then kinematics to connect acceleration to motion)

Force diagrams

- Accounting devices for your use, to keep straight forces for $\vec{F} = m\vec{a}$
- Some guidelines:
  - Draw a separate diagram for each object (book problem again!)
  - Each force gets a separate arrow
  - Draw them big enough that you can draw "component-triangles"
  - "Net force", velocity, acceleration not forces; only physical agents are

(Examples on document camera)

Force is a vector; handle it like any other

One copy of Newton's second law in each direction (per object)

$$\vec{F} = m\vec{a} \rightarrow \binom{F_x = ma_x}{F_y = ma_y}$$

Forces in 2D (and 3D)

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Important: When dealing with inclines, choose your axes to align with the incline! (F_N is easy that way)

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- "A force is something that can send you to the doctor"

A sample problem

A stack of three books sits on a table. Each book weighs 10 newtons. Draw a force diagram for each one, and calculate the size of all the forces.

(Your answer should match what you know about how this works!)

A problem-solving recipe (remember this!)

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  - Work out components (trigonometry) of vectors in funny directions – no need for numbers

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"Ask physics the question, don't tell it the answer"

Sample questions

A stone hangs from the roof of a car by a string; the car accelerates forward at 3 m/s^2.

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- What is the tension in the string?

A cart slides down a frictionless track elevated at angle θ; what is its acceleration?

Sample questions

Two masses of 20 and 40 kg hang from a massless pulley on either side. How do they move?

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Two masses of m_1 and m_2 kg hang from a massless pulley on either side. How do they move?

Summary

- Forces: anything that pushes or pulls
- Forces cause accelerations: $\sum \vec{F} = m\vec{a}$
  - If $\sum \vec{F} = 0$, $\vec{a} = 0$: motion at a constant velocity
- Forces come in pairs: if A pushes on B, B pushes back on A
- It's the vector sum $\sum \vec{F}$ that matters
- Draw force diagrams to keep all of this straight