Newton's Law of Motion

Physics 211
Syracuse University, Physics 211 Spring 2017
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February 13, 2017

Announcements

- Homework 3 due Friday
- You will get new groups in recitation tomorrow
- I am very (very) far behind on answering mail; I will catch up ASAP

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- Exam misgrades/grade appeals: talk to your TA's

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

Summary from last time

- 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

What is a force?

A force is anything that pushes or pulls something:

- Gravity: $F = mg$, so $mg = ma \rightarrow a = g$
  - Gravity pulls down on everything (on Earth) with a force mg, called its weight
  - If something isn't accelerating downward, some other force must balance its weight

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  - However big it needs to be to stop objects from sliding through each other
  - Directed "normal" (perpendicular) to the surface
  - Really caused by electric force/Pauli exclusion principle

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- Acceleration is not a force!
- ... it's the *result* of forces

Ask a physicist: static electricity

"Can we bottle it and use it to power a house?" – we already do!

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- C: Two
- D: Three
- E: Four

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Suppose an object is moving in a circle at a constant speed. Which number of forces could *not* be acting on it? (Hint: what is the definition of velocity? Of acceleration?)

- A: Zero
- B: One
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(Use $\vec{F} = m\vec{a}$ to connect force to acceleration, and then kinematics to connect acceleration to motion)

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- If two things don't touch, or interact by gravity, electricity, etc., they don't exchange forces
- "A force is something that can send you to the doctor"

A sample problem

A stack of two 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!)

Forces in 2D (and 3D)

Force is a vector; handle it like any other

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

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

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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 angle does the string make with the vertical?
- What is the tension in the string?

Sample questions

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?

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