Last lecture

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Reminders

- Last assignments are due this week:
  - Homework 14 on Thursday, April 30
  - Paper on process of science Friday, May 1
- Course evaluations are now online
- Final exam is next week

Schedule for the end of term

- Today: Walter will have help hours 3-5 PM in the Clinic.
- Wednesday, April 29: No class. Walter will have help hours 8AM-10AM in the Clinic.
- Thursday, April 30: Matt will hold a review session from 1-4 PM on Blackboard Collaborate. HW14 due.
- Friday, May 1: Walter will hold a review session from 1-4 PM on Blackboard Collaborate. Papers due at end of day.
- Saturday, May 2: Walter will hold a review session from 8-11 PM on Blackboard Collaborate.
- Monday, May 4: Final exam posted at 9AM
- Tuesday, May 5, at 11:59PM: Exam submissions due on Blackboard.

Final exam

- Final exam starts next Monday, May 4
- Take-home exam, due end of day Tuesday
- Similar to exam 3:
  - A few full problems to be scanned and submitted
  - We will have a few additional multiple choice questions on Blackboard
- The exam is cumulative
- There will definitely be questions on topics covered after the last midterm
- Some questions may use different topics in different parts

Main topics

- Four main parts of this class:
  1. Motion problems in 1 and 2D
  2. Forces and acceleration
  3. Work, energy, and momentum
  4. Rotation – rotational variables, kinetic energy, torque, and angular momentum

How to figure out what to do?

General tips

- Think about the role of time:
  - Do you need to to find motion over time?
  - Is the problem about a single instant of time?
  - Is the problem describing a before and after process?
- Do you think you can describe all the forces involved? Recall that during collisions things were basically too complicated

Kinematics

- If you know acceleration and the initial position and velocity, you can describe motion for all times
- Under constant acceleration:

$$
\begin{aligned}
x &= x_0 + v_{0,x} t + \frac{1}{2} a_x t^2 \\
v_x &= v_{0,x} + a_x t \\
y &= y_0 + v_{0,y} t + \frac{1}{2} a_y t^2 \\
v_y &= v_{0,y} + a_y t
\end{aligned}
$$

- If those conditions are true, you can use kinematics to solve problems about where something will be in the future

Forces

- If you need to find what is happening to an object just at some instant, can analyze the forces
  - Either you know the forces, want to find acceleration
  - Or you know how it is accelerating, and want to find the strength of the forces

Forces

Problem solving strategy

1. Draw a picture, identify the forces, make a free body diagram
2. Find x and y components of all the forces
3. Apply Newton's second law by setting $\sum F_x = ma_x$ and $\sum F_y = ma_y$
4. Think about what you know about the forces and accelerations:
   - Sometimes you need an extra formula (*e.g.* $f_k = \mu_k N$, $F_{\text{spring}} = -k\Delta x$, or $a = v^2/r$)
5. Solve!

Energy and momentum

- Next we tried to learn some ways to simplify situations where the forces get complicated
- Usually involved some kind of before and after problem:
  - Two things collide or push off
  - Something moves over a path, but energy is conserved

Is momentum conserved?

How do we know?

- Is there a net *external* force on the system? If no, then momentum is conserved
- Is there a net *external* torque on the system? If no, then angular momentum is conserved
- If there is a *collision* that happens essentially instantaneously, then we also say that momentum and angular momentum are conserved

Is energy conserved?

How do we know?

- Are the only forces acting conservative? Yes, energy is conserved
- Is there any other external force acting on the combined system? If so, you need to check if it does work
- Sometimes you can quantify exactly how much work is lost due to a force like friction doing work
- Sometimes you won't be able to easily write down a force you know happens: *e.g. when a collision happens you can lose energy if you aren't told the collision is elastic*

Collision problems

Strategy

1. Identify before/after the collision
   - Sometimes you need to break it down into multiple steps
2. Use equations to relate before and after:
   - $p_{i,x} = p_{f,x}$ and $p_{i,y} = p_{f,y}$ if momentum is conserved
   - $K_i + U_i = K_f + U_f$ if energy is conserved
3. Sometimes you need a little bit of extra input to solve
   - This might be simply “a solution where the objects pass through each other is not physical”

Rotation

- Rotation in a plane is analogous to 1D motion:

Position	x	Angle	θ
Velocity	v	Angular velocity	ω
Acceleration	a	Angular acceleration	α
Mass	m	Moment of inertia	I
Force	F	Torque	τ
Momentum	mv	Angular momentum	$I\omega$
Kinetic energy	$\frac{1}{2}mv^2$	Kinetic energy	$\frac{1}{2}I\omega^2$

Questions?