Slide 2 - Today

Today

• We will learn a few facts about drag forces.
• We will find work done in a number of systems.

Slide 3 - Schedule

Schedule

• Labs and HW as usual...
• Midterm #2 in class next Tuesday! - Review is Thursday.

Slide 4 - Today

Last Time

• You learned (or reviewed) how to do a wide variety of force problems.
• You learned about Newton's Law of Universal Gravitation
In-Class Test

FAQs

- What is covered?
  - HW 7-11 (8 problems)
  - HW 1-6 (2 problems - review basic questions and Midterm #1)
- What kind of problems will there be?
  - Much Like Midterm #1
  - More numerical, however
- What should I bring?
  - #2 pencil
  - calculator
  - foreign language dictionary
  - a good book?

What will happen?

1. Come 5 minutes early if you can.
2. Pick up 2 bubble sheets, a seat assignment sheet, and your test as you come in.
3. Find your seat quickly and quietly.
4. Write your name on the answer sheet
5. Write your seat # in the identification block of each bubble sheet.
6. Schedule
   A. 1:10 pm - Prayer and begin exam
   B. 2:05 pm - Turn in individual answers
   C. 2:40 pm - Turn in group answers

Seat Identification
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**Answer Sheet**

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Slide 10 - Drag Forces

**Drag Forces**

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Slide 11 - Slide 11

**Origin of Drag Forces**

Each time a little ball bounces off a very big block, its momentum changes by \( \Delta p = mv - (-mv) = 2mv \).

That imparts a momentum of \( 2mv \) in every collision.

If there are 20 collisions/s, the block picks up a momentum of \( 40 \text{ mv} \). So

\[
F = \frac{\Delta p}{\Delta t} = \frac{40 \text{ mv}}{\text{sec}}
\]

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**Origin of Drag Forces**

If the block is stationary in the air, it feels no net force because there are equal and opposite forces on both sides.
Origin of Drag Forces

But if the block is moving through the air, the forces are not equal and there is a net drag force.

Linear Drag

Small objects moving slowly through the air experience linear drag or a “linear resistive force.”

\[ \vec{F} = -bv \]

\( b \) depends on the shape and size of the object and the material through which the object travels.

Quadratic Drag

For larger objects and objects moving faster - including most everything in the “real world,”

\[ \vec{F} = -b |\vec{v}| \vec{v} \]

\[ b = \frac{1}{2} D \rho A \]

Why not write \( F = -bv^2 \) ?

Drag Equations

Drag equations are hard to solve with the tools we have now. (You need a course in differential equations.) -- But you can solve for them with a spreadsheet - like we did early in the semester.
**Terminal Velocity**

With either type of drag, the drag force increases until it equals the gravitational force. This leads to zero acceleration and a terminal velocity.

**Inclined Plane**

A mass $m$ slides without friction down the plane. How much work does the normal force do?

$W = mgd\sin\theta = mgh$

It doesn’t depend on theta!
Inclined Plane

If the block slides down the plane without friction, \( W = mgh \). What is the work done by gravity if I pull the block down the plane with a rope?

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Work and Kinetic Energy

Gravity does the same work whenever I go down the incline, and minus that amount if I go up. What about the final kinetic energies in each of these cases.
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**Double Plane**

A block slides frictionless down a plane that has two different angles. How much work does gravity do this time?

\[ h \]

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**General Result**

If I move an object with my hand from height \( h \) to height \( 0 \), how much work does gravity do?

\[ W_g = -mgh \]

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**General Result**

If I move an object with my hand from height \( h \) to height \( 0 \), how much work does gravity do?

\[ W_g = -mgh \]

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Slide 28 - Work and Gravity

**Work and Tension**
**Draggling Masses**

You pull a series of blocks a distance $d$ along a frictionless surface with an ideal rope of tension $T$. Each block has mass $m$.

What is the tension in each rope?
How much total work is done on each mass?
How much work is done on each rope?

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**Atwood's Machine**

- What is the tension in the rope?
- How much work is done by the rope on each mass in moving a distance $h$?
- How much work is done by gravity in moving a distance $h$?
- How much total work is done on the two-mass system?
- What is the total change in kinetic energy of the two-mass system?