Physics 101H

General Physics 1 – Honors

Lecture 16 – 9/27/23

Work

Midterm 1

Good News: No problem set assigned today!

More Good News: No quiz next week!

Bad News: First midterm will take place on **Wednesday October 4**!

You will have 45 minutes to complete the exam

- 3 multiple choice questions
- 2 handwritten solution problems

Bring paper and something(s) to write with! (Spare paper will be available)

Topics cover Chapters 1 to 6 and include:

- Vectors
- 1D and 2D kinematics
- Newton's laws of motion

No questions on *Motion in a medium* or *Noninertial frames*

You may prepare your own formula sheet – **one side** of **letter paper (215.9 x 279.4 mm)**

You may bring a calculator (no restrictions), but phones, tablets and laptops are not allowed

Remember you are here to learn and understand the physics!

Studying for midterm 1

Studying for the midterm:

- Look over Problem Sets
- Work through examples from class and in the textbook
- Take the practice exam, preferably under “exam” conditions

When working through problems (especially someone else’s solution):

- Cover up the solution and try to work out the next step in the solution
- If you can’t figure that out, uncover just the first step and then try to figure out the next steps
- Try to *self-explain*, that is – write down your thought process and what principles, concepts or equations are being applied at each step.

Remember that you are here to learn and understand the physics!

[But also remember there are two methods for calculating your final grade]

Summary

Topics

Monday: in-medium motion [chapter 6]

- Motion through a medium
- Models of resistance:
  - Linear and quadratic

Today: Work [chapter 7]

- Work done
- Constant force
- Varying force

Announcements

Today:	**No problem set assigned**
	Practice exam posted
Tomorrow:	**Quiz 4**
Next Wednesday:	**Midterm 1**

Work

We've been studying dynamics via Newton's laws of motion, but writing down forces and accelerations is not the only way to analyse motion

We can also think about motion in other terms

- Energy
- Conservation laws

Why would we do this? Sometimes there are situations where thinking about **scalars** (energy) is easier than thinking about **vectors** (forces).

Work

A force applied to an object does **work** on that object

Work done by the force is equal to displacement of the object times the component of the force in the direction of the displacement

Power is the rate of work done (or, as we will see, energy transferred)

If the force varies, the mathematics gets more interesting…

Example: What is the work done when compressing a spring?

Conservative forces

Conservative force: work done by a force does **not** depend on the path between those points

Nonconservative force: work done by a force does depend on the path

What was the most important equation we saw today?

Do you want a review Friday or Monday?

Summary

Topics

Today: Work [chapter 7]

- Work done
- Constant force
- Varying force

Tomorrow: Work & Energy [chapter 7 & chapter 8]

- Work-energy theorem
- Potential energy

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PHYSICS 101 - HONORS

Lecture 16 9/27/23

Work (slide 6)

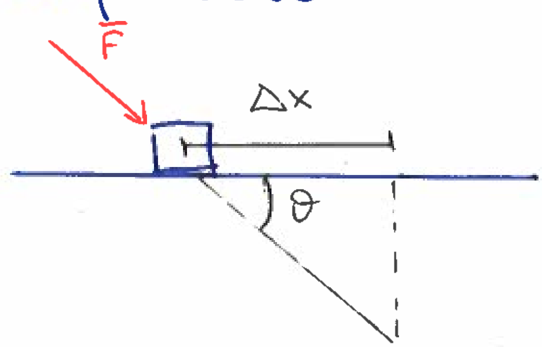
Work is a way of <u>transferring energy</u>

For a constant force

$W = \bar{F} \cdot \Delta \bar{x}$ - units $Nm \equiv$ joules

↑ scalar; vectors

Only the component of the force in the direction of the displacement does work!



$W = |\bar{F}||\Delta\bar{x}| \cos\theta$

↑ $|\bar{F}|\cos\theta$ is the component of $\bar{F}$ parallel to $\Delta\bar{x}$

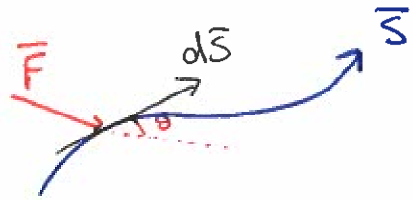
How much work does $\bar{F}$ do if $\theta = 90°$? ← None!

If the force is not constant, we chop the displacement into "little pieces" of infinitesimal length $d\bar{x}$ and then sum over all displacements

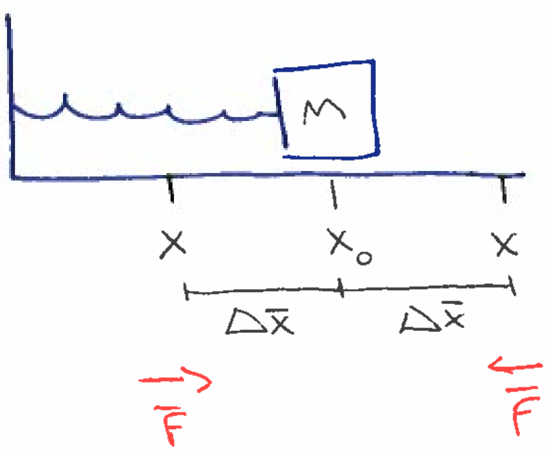
$$W = \sum_i \bar{F}_i \cdot d\bar{x}_i \longrightarrow \int_{x_1}^{x_2} \bar{F} \cdot d\bar{x}$$

If the path is not straight we must do a line integral, which accounts for $d\bar{s}$ changing direction

$$W = \int_{s_1}^{s_2} \bar{F} \cdot d\bar{s}$$



Spring example (slide 7)



Hooke's law $\bar{F} = -k\Delta\bar{x}$

Compressing the spring leads to a force that points to the right to push the spring back to equilibrium. Stretching the spring leads to a restoring force to the left to return the mass to equilibrium.

$\bar{F}$ and $d\bar{x}$ parallel but opposite $\Rightarrow \theta = 180°$
$\Rightarrow \cos\theta = -1$

$$W = \int_{x_1}^{x_2} \bar{F} \cdot d\bar{x} = \int_{x_1}^{x_2} |\bar{F}|\,|d\bar{x}| \cos\theta = \int_{x_1}^{x_2} -|F|dx$$

$$= \int_{x_1}^{x_2} (-kx)\,dx = -k\int_{x_1}^{x_2} x\,dx = -k\,\frac{x^2}{2}\Bigg|_{x_1}^{x_2} = -\frac{k}{2}\left(x_2^2 - x_1^2\right)$$

$$\boxed{W = \frac{kx_1^2}{2} - \frac{kx_2^2}{2}}$$

Conservative forces (slide 8)

We will generally consider conservative forces

Work done by a conservative force over a closed path is zero

Examples:

conservative forces	nonconservative forces
gravity	friction
spring force	drag/air resistance
electromagnetic force	

Equation summary

Work done (constant force) $W = \bar{F} \cdot \Delta \bar{x}$

$W = |\bar{F}| |\Delta \bar{x}| \cos \theta$

Work done (varying force) $W = \int_{s_1}^{s_2} \bar{F} \cdot d\bar{s}$

Work done to compress a spring $W = \frac{k}{2} (x_1^2 - x_2^2)$