Flat space, deep learning
WHO OWNS THE LEARNING?

Preparing Students for Success in the Digital Age

ALAN NOVEMBER
Ownership of learning physics?
team & project-based approach
ProTeam Learning
1 design
2 approach
Setting learning goals

Grant Wiggins and Jay McTighe, *Understanding by Design* (Prentice Hall, 2001)
Backward design

Grant Wiggins and Jay McTighe, *Understanding by Design* (Prentice Hall, 2001)
Grant Wiggins and Jay McTighe, *Understanding by Design* (Prentice Hall, 2001)
Grant Wiggins and Jay McTighe, Understanding by Design (Prentice Hall, 2001)
Ap50 is also designed to contribute to the development of the following competencies:

- **Qualitative Analysis**: The ability to analyze and solve problems in disciplines qualitatively, including estimation, analysis with uncertainty, and visual thinking.

- **Quantitative Analysis**: The ability to analyze and solve problems in disciplines quantitatively, including use of appropriate tools, quantitative modeling, numerical problem solving, and experimentation.

- **Diagnosis**: The ability to identify and resolve problems within complex systems through identification, formation and testing of a hypothesis, and recommending solutions.

- **Design**: The ability to develop creative, effective designs that solve real problems through concept creation, problem formulation, application of other competencies, balancing tradeoffs, and which integrate knowledge, beliefs and modes of inquiry from multiple and diverse fields of study.

- **Teamwork**: The ability to contribute effectively in a variety of roles on teams, while respecting everyone’s contributions. You will develop collaborative skills that may include questioning, listening, and identifying multiple approaches and points of view.

- **Communication**: The ability to convey information and ideas effectively, both positively and negatively, about any situation or the ability to think critically, both positively and negatively, about any situation or the ability to identify and address your own educational needs in a changing world, including awareness of personal attributes, fluency in use of information sources, planning, and lifelong learning.

- **Lifelong Learning**: The ability to identify and address your own educational needs in a changing world, including awareness of personal attributes, fluency in use of information sources, planning, and lifelong learning.
After successful completion of this course, you will be able to...

- Use independent study and research to tackle a problem
- Apply the scientific method to advance your knowledge and to design a system, explain why it works, and how to optimize it
- Use a variety of techniques to get a handle on problems: perform order of magnitude estimates, use dimensional analysis and symmetries, evaluate limits, and/or relate the problem to cases with known solutions
- Set up, solve, and interpret relevant equations
- Know how to evaluate the correctness of a solution
- Explain assumptions made in a model and know how to justify any approximations made
- Analyze a system, explain why it works, and how to optimize measurement in order to develop a specific design or measurement
- Use information to build a case for a specific design or measurement
- Describe how a measurement is performed and the limitations of the measuring instruments
- Use software to control simple experiments and accumulate analyze data, identify sources of uncertainty, and minimize measurement error
- Reflect on the result of a measurement in order to develop refined hypotheses
- Synthesize the data into coherent reports and presentations

**Course Goals**
Explain electrostatic interaction and conservation of charge.

Explain quantization and conservation of charge.

Describe the observations supporting the quantization and conservation of electric charge.

Define and give examples of insulators and conductors.

Describe how the charge carriers behave in insulators and conductors.

Explain polarization and how it gives rise to an electric force on a neutral object.

Describe what happens on the atomic level when a conductor (insulator) is polarized.

Explain the process of charging by induction.

Use Coulomb's law to calculate or estimate the electric force that a given charged particle or charge distribution exerts on a charged particle.

Explain the conditions in which Coulomb's law is valid.

Explain what a field is and give examples of scalar and vector fields.

Draw vector field diagrams for a simple distribution of charged particles.

Define and explain the electric field.

Explain the difference between the electric field concept and the instantaneous 'action'.

Describe a vector field by means of vector diagrams and vector function expressions.
Electric & Interaction

Conduct fundamental experiments in electrostatics and explain electrostatic interaction and the two types of charge.

Explain quantization and conservation of charge.

Describe the observations supporting the quantization and conservation of electric charge.

Define and give examples of insulators and conductors.

Describe how the charge carriers behave in insulators and conductors.

Explain polarization and how it gives rise to an electric force on a neutral object.

Describe what happens on the atomic level when a conductor (insulator) is polarized.

Explain the process of charging by induction.

Use Coulomb's law to calculate or estimate the electric force that a given charged particle, or charge distribution, exerts on a charged particle.

Explain the conditions in which Coulomb's law is valid.

Explain what a field is and give examples of scalar and vector fields.

Describe a vector field by means of vector diagrams and vector function expressions.

Explain the difference between the electric field concept and the instantaneous “action at a distance” concept.

Explain the superposition principle and apply it to determine the electric field created by a given charged particle distribution.

Draw vector field diagrams for a simple distribution of charged particles.

Design

Information transfer

Faculty-centered

Transfer
interaction
student-centered
1 design
2 approach
1st exposure deeper understanding
1st exposure deeper understanding

1st exposure deeper understanding
design

no lectures

no exams

approach
Three major components:

- information transfer (out of class)
- projects
- in-class activities
PRINCIPLES & PRACTICE OF PHYSICS

ERIC MAZUR

1 design

2 approach
Information transfer

social document annotation system

1 design

2 approach
CHAPTER 28: Magnetic Fields of Charged Particles in Motion

In this chapter, we investigate further the relationship between the motion of charged particles and the occurrence of magnetic fields. As we shall see, all magnetism is due to charged particles in motion, whether moving along a straight line or spinning about an axis. It takes a moving or spinning charged particle to create a magnetic field, and if it takes another moving or spinning charged particle to "feel" that moving or spinning charged particle to create a magnetic field. We shall also discuss various methods for creating magnetic fields, which have wide-ranging applications in electromechanical machines and instruments.

28.1 Source of the Magnetic Field

As we saw in Chapter 27, magnetic interactions take place between magnets, current-carrying wires, and moving charged particles. Figure 28.1 summarizes the magnetic interactions we have encountered so far. Figures 28.1a-c show the interactions between magnets and current-carrying wires. The sideways interaction between a magnet and a current-carrying wire (Figure 28.1b) is unlike any other interaction we have encountered. The forces between the wire and the magnet are not central—they do not point directly from one object to the other. As we saw in Section 27.7, the magnetic force exerted on a current-carrying wire is the sum of the magnetic forces exerted on many individual moving charge carriers. Similarly, the magnetic field due to a current-carrying wire is the sum of the magnetic fields of many individual moving charge carriers. Figures 28.1d and 28.1e illustrate the interactions of moving charged particles. Note that for two charged particles moving parallel to each other (Figure 28.1e), there is in addition an attractive magnetic force, a much larger repulsive electric force.

It is important to note that the magnetic interaction depends on the state of motion of the charged particles. No magnetic interaction occurs between a bar magnet and a stationary charged particle (Figure 28.1f), or between two stationary charged particles (Figure 28.1g). These observations suggest that the motion of charged particles might be the origin of all magnetic phenomena. There are two problems with this assumption, however. First, the magnetic field of a wire carrying a constant current looks very different from that of a magnet (Compare Figures 27.13 and 27.19). Second, there is no obvious motion of charged particles in the presence of a magnetic material. Figure 28.2a shows the magnetic field lines...
Student 1 – 25 Feb, 04:55PM
Yeah, this is where I’m confused. From the first paragraph: “It takes a moving or spinning charged particle to create a magnetic field...” however there is no obvious motion of charged particles in a piece of magnetic material (bar magnet for example?). How does this reconcile?

Student 2 – 26 Feb, 08:29PM
Maybe they are trying to say that there is no OBVIOUS motion, but they are in fact moving via a current. Therefore, it meets their definition that it takes moving particles to create a magnetic field.

Student 3 – 2 Mar, 09:00AM
I agree that the motion is not “obvious” in that it is not visible to the naked eye. The cause must be atomic.

Student 2 – 2 Mar, 11:37AM
Oh the answers to this question kind of address my question above - I guess there isn’t a force if the particle is stationary, but since even when an object is stationary (thus no obvious motion), there is a magnetic force. It’s when everything, including the particles, are stationary that there is no obvious motion.

Student 4 – 4 Mar, 01:05PM
Is there ever a situation in reality where everything, even the particles are not ...
Student 1 – 25 Feb, 04:55PM
Yeah, this is where I’m confused. From the first paragraph: “It takes a moving or spinning charged particle to create a magnetic field...” However, there is no obvious motion of charged particles in a piece of magnetic material (bar magnet for example?). How does this reconcile?

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Student 4 – 4 Mar, 01:05PM
Is there ever a situation in reality where everything, even the particles are not...
### Annotation Rubric

Your annotations of the textbook on NB will be evaluated on the basis of quality, quantity, and timeliness, as shown below. Your goal in annotating each chapter is to demonstrate *timely and thoughtful reading of the text.* When we look at your annotations we want them to reflect the effort you put in your study of the text. It is unlikely that that effort will be reflected by just a few annotations per chapter, unless your annotations are unusually thoughtful and stimulate a deep discussion. About 7–20 *thoughtful* annotations per chapter spread out over the chapter is about right, but keep in mind that quality is more important than quantity!

About 4 days after the deadline of the last chapter in each unit, we will provide an overall assessment of your annotations in that unit using the usual three-point scale (0–3), by combining your annotation scores for the three categories.

#### Quality

The textbook replaces the lectures (us reading the textbook to you) so that we can do more interesting things in class. Therefore it is important you read the text thoughtfully and attempt to lay the foundation for the work in class.

- **2** = Demonstrates thorough and thoughtful reading AND insightful interpretation of the chapter
- **1** = Demonstrates reading, but no (or only superficial) interpretation of the chapter
- **0** = Does not demonstrate any thoughtful reading of the chapter

See the examples on the next page to see the quality criterion applied to sample annotations.

#### Quantity

To lay the foundation for understanding the in-class activities, you must at least familiarize yourself with the entire chapter — not just the first few pages.

- **2** = 7–20 thoughtful annotations that cover each section of the chapter
- **1** = 7–20 thoughtful annotations, but not each section is annotated
- **0** = 6 or fewer annotations

#### Timeliness

The work done in class depends on you having done the reading in advance, so completing the reading on schedule is important. Your annotations can be questions, comments, or responses to existing questions or comments. Responses are allowed up to three days beyond the posted deadlines.
Information transfer

Annotation rubric

- Quality (must be thoughtful)
- Quantity (7–20 thoughtful & distributed)
- Timeliness

1 design
2 approach
### Information transfer

#### Unit 6 - Unit 10

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<th>Ch 22-24</th>
<th>Ch 25-26</th>
<th>Ch 27-29</th>
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<tbody>
<tr>
<td>electrostatics</td>
<td>potential and charge separation</td>
<td>magnetism</td>
<td>electromagnetism and circuits</td>
<td>optics</td>
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</tbody>
</table>

#### Learning Catalytics (Sync)

- Reading out of class
- In class and repeating for each unit
- Tutorial
- Estimation activity
- Readiness assurance (Sync)
- Problem set reflection (Sync)
- Experimental design activity

#### Project Fair

- ECOTRICITY

#### CRACKATHON

- January 26, February 3, March 12, April 23, May 28

#### inSPECT FAIR

- March 31, April 2, May 7, June 9, July 14, August 16, September 21

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#### Reading Schedule

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- Sections 27.4 and 27.8 optional

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1. **design**
2. **approach**
Information transfer

1 design

2 approach

showing information transfer in various units and chapters:
- Unit 6
- Unit 7
- Unit 8
- Unit 9
- Unit 10
- Ch 22-24
- Ch 25-26
- Ch 27-29
- Ch 30-32
- Ch 33-34

Electrostatics
Potential and charge separation
Magnetism
Electromagnetism and circuits
Optics

Learning catalytic (sync) reading
Out of class
In class and repeating for each unit
Tutorial
Estimation activity
Readiness assurance (sync)
Problem set reflection (sync)
Experimental design activity
Project fair

27 29 3 5 10 12 17 19 24
666
7 8 8
8
22–34
6–10
T, P
chapter to be read
unit
team assignment, project proposal review

Sections 27.4 and 27.8 optional

Chapter deadline

Reading schedule

Jan
Feb
Mar
Apr

Table of contents:
- Introduction
- Chapters 22-34
- Sections 6, 7, 8, 8, 8, 9, 10
- Sections 27.4 and 27.8 optional

Legend:
- Units
- Reading schedule
- Class schedule

Increasing mastery
Chapter deadline
Information transfer

1. design
2. approach

unit deadline

sections 27.4 and 27.8 optional

chapter deadline

105%
### Information transfer

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- **Electrostatics**
- **Potential and charge separation**
- **Magnetism**
- **Electric magnetism and circuits**
- **Optics**

#### Learning Catalytics (Sync)
- Reading | out of class
- Tutorial | in class and repeating for each unit
- Estimation activity
- Readiness assurance (Sync)
- Problem set reflection (Sync)
- Experimental design activity
- Project fair

#### Schedule

<table>
<thead>
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<th>Reading Schedule</th>
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<tr>
<td><strong>Jan</strong> 27 29 3 5 10 12 17 19 24</td>
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#### Milestones

- **Unit deadline**
- **Chapter deadline**
- **Three extra days for answers to questions**
Information transfer

95% of students complete all readings!

1 design

2 approach
Projects

1 design
2 approach
Projects

- 1 projects/month (6 over 2 semesters)
- new team formation for each project
- projects not prescriptive, but open-ended
- 3 types of project “fairs”
- external evaluators
Projects

Project fair types:

• design competition
• oral presentation
• poster presentation
Projects

Rule-based team formation using GroupEng

www.GroupEng.org
Projects

Rule-based team formation using GroupEng

- gender
- year
- self-efficacy & learning attitude
- class performance
- exclude previous team mates

www.GroupEng.org
Projects

To be successful, the projects must

• require practical application of skills
• be linked to real world problems
• have compelling narrative (help/do good)
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<td><strong>Fall</strong></td>
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<td>Rube Goldberg</td>
<td>Mission to Mars</td>
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<td>Symphosium</td>
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<td><strong>Spring</strong></td>
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<td>Ecotricity</td>
<td>Crack-a-Thon</td>
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<td>inSPECT Fair</td>
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1 design 2 approach
Projects

Fall

Rube Goldberg

Spring

Ecotricity

Mission to Mars

Crack-a-Thon

Symphosium

inSPECT Fair

1 design

2 approach

AP50 FALL 2014

Project Brief

Symphosium
1 design
2 approach
Projects

1. design

2. approach
Build a beautifully sounding instrument from recycled parts
Projects

Build a beautifully sounding instrument from recycled parts

• musical range
• $Q$-factor
• harmonic spectrum
• sound level
• tuning stability
Projects

Milestones:

• team contract
• proposal
• fair
• report
• team, peer, and self assessment
Projects

Milestones:

• team contract (at beginning)

• proposal

• fair

• report

• team, peer, and self assessment
Projects

Milestones:

• team contract (at beginning)
• proposal (+1 week)
• fair
• report
• team, peer, and self assessment
Projects

Milestones:

- team contract (at beginning)
- proposal (+1 week)
- fair (+3 weeks)
- report
- team, peer, and self assessment
Projects

Milestones:

• team contract (at beginning)
• proposal (+1 week)
• fair (+3 weeks)
• report (+1 week +3 days for revision)
• team, peer, and self assessment
Projects

Milestones:

- team contract (at beginning)
- proposal (+1 week)
- fair (+3 weeks)
- report (+1 week +3 days for revision)
- team, peer, and self assessment (at end)
1 design
2 approach
1 design  2 approach
competition instead of social good/empathy as motivator
In-class activities

1 design
2 approach
In-class activities

2 weekly 3-hour class periods
In-class activities

**blend of 6 “best practices”**

**LC: Learning Catalytics** 90 min
- Instructor poses question
- Answer alone
- Discuss in team
- Answer again
- bring device

**Tutorial** 60 min
- Work on worksheet with team
- Explore concepts
- Discuss with staff

**Problem Set & Reflection** 90 min
- Work problems alone BEFORE class
- Discuss with team, mark up
- Self-assess & turn in

**RAA: Readiness Assurance Activity** 90 min
- Part 1: solve problems alone
- Open book, open internet
- Part 2: solve with team
- bring device
In-class activities

1. design
2. approach
In-class activities

one project

1 design

2 approach
In-class activities

2/3 scaffolded, guided

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1. design
2. approach
In-class activities

1/3 unguided
In-class activities

team intro

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1 design

2 approach
In-class activities

1. design
2. approach
In-class activities

- **Ch 22-24**
  - Electrostatics
  - Potential and charge separation
- **Ch 25-26**
  - Magnetism
- **Ch 27-29**
  - Electromagnetism and circuits
- **Ch 30-32**
  - Optics

**Unit 6**

- Learning catalysis (sync)
- Reading out of class

**Unit 7**

- In-class and repeating for each unit

**Unit 8**

- Tutorial estimation activity
- Readiness assurance (sync)
- Problem set reflection (sync)

**Unit 9**

- Experimental design activity

**Unit 10**

- Project fair
In-class activities

1. Design

**LC: Learning Catalytics** 90 min
- Instructor poses question
- Answer alone
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- Answer again
- Bring device

**Tutorial** 60 min
- Work on worksheet with team
- Explore concepts
- Discuss with staff

**EA: Estimation Activity** 30 min
- Estimate quantities
- Develop individual strategy
- Discuss and solve as team

**EDA: Experimental Design Activity** 90 min
- Conduct experiment with team
- Take measurements
- Analyze data
- Carry out simulations
- Bring device

**Problem Set & Reflection** 90 min
- Work problems alone BEFORE class
- Discuss with team, mark up
- Self-assess & turn in

**RAA: Readiness Assurance Activity** 90 min
- Part 1: solve problems alone
- Open book, open internet
- Part 2: solve with team
- Bring device

2. Approach
In-class activities

**LC: Learning Catalytics**  90 min
- Instructor poses question
- Answer alone
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- Answer again

**Tutorial**  60 min
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In-class activities

1. **Design**

   - LC: Learning Catalytics 90 min
     - Instructor poses question
     - Answer alone
     - Discuss in team
     - Answer again
     - bring device

2. **Approach**

   - Tutorial 60 min
     - Work on worksheet with team
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     - Discuss with staff

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In-class activities

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<td></td>
</tr>
<tr>
<td></td>
<td>Part 2: solve with team</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluate</th>
<th>EDA: Experimental Design Activity</th>
<th>90 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conduct experiment with team</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Take measurements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analyze data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carry out simulations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bring device</td>
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</tbody>
</table>
### In-class activities

<table>
<thead>
<tr>
<th>Understand</th>
<th>LC: Learning Catalytics</th>
<th>90 min</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Instructor poses question</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer alone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discuss in team</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer again</td>
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</table>

<table>
<thead>
<tr>
<th>Apply</th>
<th>EA: Estimation Activity</th>
<th>30 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate quantities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop individual strategy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discuss and solve as team</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluate</th>
<th>Work problems alone BEFORE class</th>
<th>90 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discuss with team, mark up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-assess &amp; turn in</td>
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</table>

<table>
<thead>
<tr>
<th>Evaluate</th>
<th>RAA: Readiness Assurance Activity</th>
<th>90 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Part 1: solve problems alone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open book, open internet</td>
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</tr>
<tr>
<td></td>
<td>Part 2: solve with team</td>
<td></td>
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<table>
<thead>
<tr>
<th>Evaluate</th>
<th>Tutorial</th>
<th>60 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Work on worksheet with team</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Explore concepts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discuss with staff</td>
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</tbody>
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<thead>
<tr>
<th>Evaluate</th>
<th>EDA: Experimental Design Activity</th>
<th>90 min</th>
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<td></td>
<td>Carry out simulations</td>
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</table>

**1 design**

**2 approach**
In-class activities

**Instructor poses question**
- Answer alone
- Discuss in team
- Answer again

**Work on worksheet with team**
- Explore concepts
- Discuss with staff

**Estimate quantities**
- Develop individual strategy
- Discuss and solve as team

**Conduct experiment with team**
- Take measurements
- Analyze data
- Carry out simulations

**Work problems alone BEFORE class**
- Discuss with team, mark up
- Self-assess & turn in

**Part 1: solve problems alone**
- Open book, open internet

**Part 2: solve with team**
- Bring device