BEFORE CLASS:
PLAY WITH GLASS, PLASTIC, SILK AND FUR TO GET A REPULSIVE FORCE AT A DISTANCE

RECITATIONS START THIS FRIDAY!

FIRST HOMEWORK ASSIGNMENT IS DUE IN CLASS NEXT TUESDAY!!

class web site
http://www.physics.rutgers.edu/ugrad/227H
Physics 227H: Honors Analytical Physics II

electricity and magnetism

Problem solving techniques and strategies
Both numerical and symbolic
More conceptual, more mathematical than 227
Electricity and magnetism

Textbook:
Halliday, Resnick and Walker, 10th edition
the instructors

Prof. Karin Rabe (lectures): theoretical materials physics
PhD in physics from MIT 1987
AT&T Bell Labs 1987-1989, on the faculty at Yale 1989-2000
on Rutgers faculty since 2000
Board of Governors Professor and member of the National Academy of Sciences, 2013

Hardik Routray
recitations; PhD student in experimental particle physics

Mai Ye
recitations; PhD student in experimental condensed matter physics
The lectures

55 minutes, 2x per week + a LOT of material
This can only work with our full attention!

CLASS RULES
NO talking, except to address the entire class
Use of electronics (cell, tablet, laptop) is strongly discouraged
No eating (drinking is OK)

want to get the maximal benefit for effort put in
Demonstrations – the best part!

Dave Maiullo

World-leading physics demonstrator

As seen on the Discovery Channel, in our textbook demo videos, in bars and nightclubs, and in “That Physics Show” currently playing off-Broadway
The recitations

55 minutes, 1x per week
Taught by PhD students Hardik Routray and Mai Ye

• Math topics
• Solving example problems as a bridge between the lectures and the homework
Pre-recitation problems

These are the “easy” warm-up problems that review the physics you have learned before and help you transition to the problems assigned in the homework.

Two problems will be assigned in each lecture.

You should do the problems BEFORE recitation and if you have any difficulties, visit the background reading link or ask one of the instructors.

Bring the problems and your solutions to recitation for discussion/presentation.
Homework

Due Tuesdays 11:59 PM
WebAssign rutgers 5607 1563
Office hours

Sunday 6:00-7:30 PM on College Ave (?)

TA office hours will be during the week on Busch
Coursework and Grades

Exam 1: 15%, Exam 2: 20%, Final: 30%, HW: 20%, Quiz 15%

Clickers will be used in lectures but attendance is not part of the grade

Exam I: early/mid October
Exam II: mid/late November
Final Exam: during exam period

First recitation this week
1st HW due: Tuesday September 10 at 11:59PM
N2: \[ \vec{F} = m\vec{a} \]

If acceleration of an object is nonzero, there must be a net force on the object.

Force and acceleration are VECTORS, direction and magnitude.

Types of forces that you have learned about in Honors Analytical Physics I.
Types of forces that you learned about in Analytical Physics I

**Contact forces:**
“applied” force = push
normal force (at a surface)
String tension: pull
Spring: pull, push
Static and kinetic friction, drag force

**Force at a distance:**
gravity
Gravity
Acts at a distance
Attractive
very small
Proportional to mass
# A new force

<table>
<thead>
<tr>
<th>Gravity</th>
<th>new force</th>
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<tbody>
<tr>
<td>Acts at a distance</td>
<td>Acts at a distance</td>
</tr>
<tr>
<td>Attractive</td>
<td>Attractive AND repulsive</td>
</tr>
<tr>
<td>very small</td>
<td>easy to make large</td>
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<tr>
<td>Proportional to mass</td>
<td>proportional to “electric charge”</td>
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</table>
Electricity and magnetism

Focus on fields as fundamental entities
Electric field $\mathbf{E}(\mathbf{r})$
Magnetic field $\mathbf{B}(\mathbf{r})$

First example of a classical field theory
First example of a unified theory
Electromagnetism

\[ \nabla \cdot E = \frac{\rho}{\varepsilon_0} \quad \nabla \cdot B = 0 \]

\[ \nabla \times E = -\frac{\partial B}{\partial t} \quad \nabla \times B = \mu_0 j + \frac{1}{c^2} \frac{\partial E}{\partial t}. \]

Maxwell’s equations: fields, charge, current

\[ F = q(E + \mathbf{v} \times \mathbf{B}). \]
Electromagnetism

\[ \oint \vec{E} \cdot d\vec{A} = q_{\text{enc}}/\varepsilon_0 \quad \oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt} \]

\[ \oint \vec{B} \cdot d\vec{A} = 0 \quad \oint \vec{B} \cdot d\vec{s} = \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} + \mu_0 i_{\text{enc}} \]

Maxwell’s equations: fields, charge, current

\[ \mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}). \]
Electrostatics: HRW Chapters 21-25

\[ \oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enc}}}{\varepsilon_0} \quad \oint \vec{E} \cdot d\vec{s} = 0 \]

Maxwell’s equations: electric field & charge

\[ \mathbf{F} = q \mathbf{E} \]
A new force

Gravity
Acts at a distance
Attractive
very small
Proportional to mass

new force
Acts at a distance
Attractive AND repulsive
easy to make large
proportional to “electric charge”

Charge, like mass, is a scalar property of objects/particles. Mass is positive Charge can be positive or negative

Masses attract
Like charges repel
opposite charges attract
Force laws for two point particles

**Law of gravity**
Force on particle 2 due to particle 1 is directly towards particle 1
Magnitude depends on inverse square of separation
Unit of mass is kilograms (kg)
\[ G = 6.67408 \times 10^{-11} \text{ N m}^2/\text{kg}^2 \]

**Law of electric force (Coulomb’s law)**
Force on particle 2 due to particle 1 is along line connecting them
Magnitude depends on inverse square of separation
Towards particle 1 if \( q_1 q_2 < 0 \), away if \( q_1 q_2 > 0 \)
Unit of charge is Coulombs (C)
\[ k = 8.99 \times 10^9 \text{ N m}^2/\text{C}^2 \]
Force on particle 1 due to particle 2 satisfies Newton’s 3\(^{rd}\) law
**SUPERPOSITION**: forces on particle add like vectors
Compute the gravitational and electric forces for two protons
Example:

What is the direction of the net electric force on the middle particle, if the particles on the x axis are equidistant from the origin?