Physics 33131

Matter & Interactions I

Instructors: Professor Curtis Meyer

Course Website: http://www-meg.phys.cmu.edu/physics_33131/
check this regularly as all assignments and announcements will be posted here. We will not distribute paper copies in class.

Lectures: Monday, Wednesday & Friday 8:30-9:20

Recitations: Tuesday & Thursday Sec A: 9:30-10:20
Sec B: 10:30-11:20
Sec C: 11:30-12:20
Sec D: 12:30-1:20
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Experimental Medium Energy Particle Physics

My research is carried out at the Thomas Jefferson National Accelerator Laboratory (Newport News, VA)

“Why are quarks forever trapped inside protons and neutrons?” (The GlueX experiment)
Course Web Site

http://www-meg.phys.cmu.edu/physics_33131/

A detailed archive of all course information:
Textbook

Matter & Interactions Volume 2
Modern Mechanics

Ruth Chabay and Bruce Sherwood


We will cover nearly all of the textbook this semester.

There is also a website with errata and updates:
http://www.wiley.com/college/chabay/
Course Grade

3 “hour” Exams @ 15% Each                45%
2 Comprehensive Final                     30%
Assignments and Programs                  15%
Quizzes                                    5%
Attendance                                 5%

Grading will be on an absolute scale:

88% to 100%        A
75% to 87%         B
60% to 74%         C
47.5% to 59%       D

This can be lowered, but not raised.
Exams

Exam 1  
Friday September 26  8:30-9:20am

Exam 2  
Friday October 24   8:30-9:20am

Exam 3  
Friday November 21  8:30-9:20am

I will be in the class room at 8:00am and you will be allowed to start the exam at that time. You are not required to start at 8:00am!

If you have a University Sponsored Conflict, let me know no later than 2 weeks before the exam.

The final will be a three hour exam and will be scheduled by the Registrar - watch the Tartan for details.
Homework

You are encouraged to work together on your homework, and to ask lots of questions. Scientists solve problems by working in groups and we want to make sure that this happens.

Anything that you turn in needs to be your own work. I will not accept copies of other’s papers.

There will be homework due every week during class on Friday. Late Assignments will not be accepted Without prior approval of an instructor.

Due on August 29: 1.RQ.54, 2.RQ.17, 2.RQ.18, 2.RQ.19, 2.P32
Quizzes

There will be a short (10 minute) quiz held during the Friday lecture nearly every week. The exact schedule is posted on the course web site.

These will be based on either the homework that you just turned in, or the exercises that you worked on in recitation during the week. Coming to class and doing your homework should be sufficient study for these.

The purpose of the quizzes is to give you continual feedback on your mastery of the subject.
Coming to Class

Participation in the in-class activities is an important part of the learning process. As such, I will base roughly 5% of your grade on attendance in both lecture and recitation.

This component of your grade will be most important if your grade is on the boundary between two grades.
Course Center

The recitation room, Doherty Hall A325, will be open on Wednesday evening from 6:00pm till 9:00pm and on Thursday evening from 6:00pm until 9:00pm. There will be instructors there to answer questions, and the computers will be available.

I strongly encourage you to take advantage of this to get together and work on physics with other students.

There will be no course center on Aug. 27 & 28
Course Goals

Model a broad range of physical phenomena using a small set of powerful fundamental principles.

Explain the nature of matter and its interactions in terms of a small set of physical laws that govern all mechanical interactions and in terms of the atomic structure of matter.

Learn to make reasonable assumptions and approximations. To be able to solve complicated problems, then understand if the answer you have is reasonable or not.
Physical Modeling

An important part of M&I is modeling of real world situations using computer simulation. This is done using the Vpython program:

http://vpython.org/

You can download and install this on your own computer. It is also installed on the clusters.

This is not a programming class, and no prior programming experience is required.
Lectures

Lectures will present new material, have demonstrations of physical concepts and involve concept questions to help you gauge if you are understanding the material.

I want the lectures to be as interactive as possible, so please do not hesitate to ask questions or make comments.
Recitations

Recitations meet on Tuesday and Thursday and will involve two types of activities:

- Modeling of Physical Systems using Computers
- Working out Physics problems in groups

The recitations are designed to reinforce and solidify the material that is presented in lectures. Many students find that this is where they really master the material.
Enrollment

DH A325 will hold about 22 students, and has 18 computers in it.

Section A  8:30am      22 Students
Section B  9:30am      26 Students
Section C 10:30am     16 Students
Section D 11:30pm     18 Students
Feeling Overwhelmed?

The course center is a good place to start for help. Regularly attending these will make a difference.

Meet with an instructor nearly any time you want to - just drop by with questions.

If you find that this course is just too much, and that you don’t have the time needed to keep up, it is possible to transfer into the 33-111 course. Last Possible date is 3 weeks into the course.

33-111 uses the same book, but covers less material.
A model is a simplified description of the world which is able to predict observed phenomena.

A model is NOT a perfect description
It may have approximations.
It may not cover all cases.
What is good and what is not good? When do things stop working?

What is wrong with this?
Gravity not constant
Air Friction
Relativity

......

Will this work for a piece of paper?
Interactions

We will describe the world in terms of Interactions - which can be associated With a fundamental force of nature

Gravitation: Holds us to the surface of the Earth. Causes the Moon to orbit the Earth, the Earth to orbit the Sun, ..... ONLY ATTRACTIVE

Electric Interaction: Holds atoms together. Keeps us from sinking to the center of the Earth. ATTRACTIVE and REPULSIVE

Strong Nuclear Force: Acts inside a nucleus, holds protons together. Quantum Chromodynamics, very short range, ATTRACTIVE AND REPULSIVE

Weak Nuclear Force: Causes the Sun to Burn. Responsible for changing particles from one to another.
### Standard Model of Fundamental Particles and Interactions

#### Fermions
- **Leptons**
  - \( \ell \) electron, neutrino
  - \( \ell \) electron, \( \bar{\ell} \)\( \text{neutrino} \)
- **Quarks**
  - \( q \) up, \( \bar{q} \) down
  - \( q \) charm, \( s \) strange

#### Bosons
- \( \gamma \) photon
- \( W^+ \), \( W^- \), \( Z^0 \)

#### Properties of the Interactions
- **Gravitational**
- **Weak**
- **Electromagnetic**
- **Strong**

#### Matter and antimatter
- Every particle has an antiparticle.

#### Figures
- Diagrams illustrating the decay of particles and their interactions.

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**Unified Electroweak**
- Spin: \( 1 \)
- Electric charge: \( q \)

**Strong (color)**
- Spin: \( 8 \)
- Electric charge: \( q \)

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**Residual Strong Interaction**
- The force that holds color-neutral protons and neutrons to form nuclei is due to residual strong interactions between their color-charged constituents.
Unification
Are all the forces part of a single more fundamental force?

Balls bounce around:

If Energy Low - disconnected.
If Energy Medium - cross talk
If Energy High - all places allowed

Same with forces.

Inside a proton: \(< 80 \, m_p < 10^{15} \, m_p < 10^{19} \, m_p\)
Interaction Occurred

Something changed - good indication that an interaction occurred.

Dots are 1 second apart.

$\Delta = \text{Change}$

Interactions are related to forces and cause changes in Momentum.
Newton’s First Law

An object moves in a straight line and at constant speed except to the extent that it interacts with other objects.

An astronaut (in space) shoots a pellet out of a spiral tube. Which path does it follow?

- A
- B
- C

B because there is no interaction.
Relativity Principle

*Physical laws work in the same way for observers in uniform motion as for observers at rest.*

“Inertial Reference Frames”

\[ \vec{F} = m \vec{a} \]

Throw a ball up into the air:

**Observer at rest:**

- Initial Conditions:
  \[ \vec{v}_i = v_o \text{ (up)} \]
  \[ y_i = y_o \]

**Observer at constant velocity**

- Initial Conditions:
  \[ \vec{v}_i = v_o \text{ (up)} + v_p \text{ (right)} \]
  \[ y_i = y_o \]

\[ \vec{r}(t) = \vec{r}_i + \vec{v}_i t + \frac{1}{2} \vec{g} t^2 \]
Relativity Principle

*Physical laws work in the same way for observers in uniform motion as for observers at rest.*

“*Inertial Reference Frames*”

As seen from an observer on the ground, what path does the ball follow?  **B**

As seen from an observer on the plane, what path does the ball follow?  **D**