Physics 1301
Where to Find It

- Class Web Page
  - http://www.physics.umn.edu
    - » Class Information
    - » 1301.100
  - Syllabus can be downloaded from web
    - » Schedule
    - » Grading
  - Lecture notes
  - Text problem solution outlines
  - Office hours & email addresses
  - Announcements
  - Interesting physics links
- Read Syllabus
  - Need to buy
    - » Text (bookstore)
    - » Lab Manual(web or bookstore)
    - » Lab Journal (bookstore)
    - » Competent Problem Solver(bookstore)
    - » Index Cards (bookstore)
- Questions about course (tomorrow)

1

Tomorrow's Assignment

- Before Tomorrow
  - Read Syllabus Carefully
  - Read Text Chapter 1, 2
  - Do problems Chapter 1
  - Read Competent Problem Solver Chap. 1, 2
- Before next Monday
  - Read Competent Problem Solver Chap. 3
  - Do Text Problems Chapter 2
  - Take Pre-lab Computer Quiz
  - Read Assigned Problems in Lab 1 and do predictions and methods questions

2

Introduction to Physics
For Engineers & Scientists

- Understand the behavior of everything
  - Formulate Theories to Predict Behavior
    - » Qualitative
    - » Quantitative
- Develop Problem Solving Strategy
- Develop Technical Communication Skills
- Physics 1301
  - Behavior of objects when they interact
- Physics 1302
  - The most useful interactions - Electricity & Magnetism
- Physics 2503
  - The physics most important to 20th Century technology
    - » Electromagnetic waves
    - » Optics
    - » Physics on the atomic scale

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Course Structure

Lectures

My job
- Tell you why
- Show you how

Your job
- Read the text before coming to lecture
- Connect lectures to what you know
- Ask if it doesn't make sense to you
  - Your neighbor
  - Me

Participating in Lectures is not enough

You need to practice to understand

Practice in many different situations

Discussion section — Organized Feedback
Laboratory

By yourself
Office hours
Study group

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Physics

Trying to understand

The Universe

Observe	Infer
Objects	Interactions
Their Motion	

The Universe operates the same way for

Everything

Everywhere

Words do not always mean the same for everyone.

Careful definitions

Mathematics

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PHYSICS

Goal:

Determine the interactions between the objects

Why?

Curiosity and understanding

Control

One effect of an interaction:

- interacting objects change their motion

We need to precisely describe the effect of an interaction on the motion of an object.

We need to precisely describe the motion of an object.

We construct theories about how it all works.

Physics is a construct of the mind.

Physics is not TRUTH

Physics works very well

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Physics is about everything.

Divide our Universe into:

Objects

Interactions

Objects have properties

mass, charge, density....

Objects have relationships to other objects

position, velocity, acceleration

Interactions have properties

strength, variation, ...

Groups of objects - systems

properties

descriptions

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Your Theory of Physics

Everyone has one

You have survived in the Universe

Using Your Theory of Physics

Your personal Theory of Physics

Mostly correct

but

Some is not

This course is about examining

Your Theory of Physics

- Correct it when necessary
- Make it more useful with powerful tools
  - •Problem solving
  - •Communication
  - •Mathematics

An example of how to do it comes next

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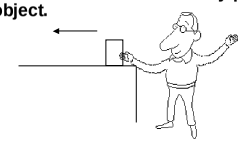
Interactions & Motion

The Experiment--Start with an object at rest on a table.

observe — The object doesn't move.

infer — There is no interaction.

Now cause an interaction by pushing the object.

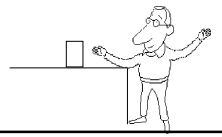


observe

The object moves.

The harder you push, the faster it moves.

You stop pushing.



observe

The object stops.

infer

Their is no interaction.

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DESCRIBE THE RESULTS

GENERALIZE

Make a model or theory

QUALITATIVE DESCRIPTION

An objects moves (changes position) only when a push or pull (force) is applied to that object.

The change of position in a given amount of time (speed) is greater if the applied force is greater.

QUANTITATIVE DESCRIPTION
(Math Translation)

(Speed) = (Force) x (A Constant Something)

CHECK

- If Force = 0 than Speed = 0
- If Force increases, then Speed increases
- S = kF

Why not $S = \sqrt{kF}$, $S = kF^2$, or $S = kF^3$?

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Go To the Laboratory

- To decide which theory we want, we must measure S as a function of F .
- We must describe how to measure these quantities, and this description becomes the definition of the quantity .

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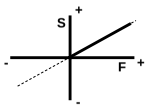
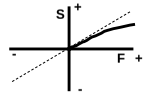
PREDICTION

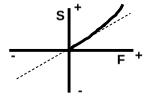
What do we expect the results will be when we make the measurements?



S = kF



$S = \sqrt{kF}$



$S = k F^2$

For what values of S or F do we make our measurements?

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Before we begin to do this time consuming experiment,

can you think of any observation you have already made that disagrees with all of the theories of motion we made.

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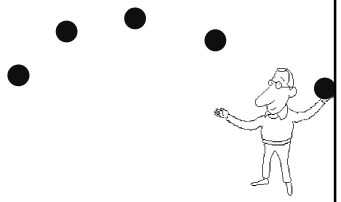
Throwing



Does the ball's motion agree with the theories of the type S = kF ?

Why or why not?

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Can we explain the motion
of an object on a table
and
an object thrown through the air
using a single theory?

We will have explained an event if
we can predict the motion completely.

In this case
we must predict the object's path (trajectory)
and
its speed along that trajectory
for a given interaction.

Examine your personal set
of physics theories.

Predict (draw) the ball's trajectory .

Describe the behavior of the ball's speed
as it moves along the trajectory.

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Plan for 1301

- Careful description of motion
  - Position, time
  - Speed, velocity
  - Average, instantaneous
  - Acceleration
- Theory of interaction
  - Forces
  - Energy
  - Momentum
  - Torque
  - Angular momentum
- Applications
  - Math
    - Calculus practice
    - Use in Physics before math class
  - Problem Solving
    - Logical Procedure
    - Well Communicated

- Use only the most important equations.
- No other "formulas" allowed.

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Describing Motion

Start with simple situations
Straight line motion

Examine your existing knowledge
Careful definitions
Useful mathematics

Try solving the following problem using a logical and well-communicated procedure.

After solving the problem

Carefully review the meaning of
Speed
Velocity
Acceleration
Average

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Example problem

While waiting in the dentist's office the only thing there is to read is one of those awful puzzle books. Since you are bored, you read the following "brain teaser". Two trains leave different stations 80 km apart and travel toward each other on a straight track. One train has a speed of 80 km/h, and the other has a speed of 160 km/h. A very fast insect leaves the slower train and heads toward the faster train at a speed of 240 km/h. Upon encountering the second train, it turns around and just as rapidly returns to the first train. It continues these maneuvers until it is squashed between the two trains when they collide. How far did the insect fly? You know physics so you should be able to solve it.

Apply a problem solving strategy.

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Problem Solving Technique

Used by experts in all fields

How to solve a problem you don't know how do

STEP #1 Recognize the Problem
What's going on?

STEP #2 Describe the problem in terms of the field
What does this have to do with ..... ?

STEP #3 Plan a solution
Can I use what I know to get an answer?

STEP #4 Execute the plan
Get an answer

STEP #5 Evaluate the solution
Can this be true?

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Problem-Solving Strategy for Physics Problems

STEP #1 Focus the Problem

Visualize the situation.
Draw a sketch.

What is the question?

What general approach may be work?

STEP #2 Physics Description

Define the relevant quantities:
Diagrams
Coordinate system
Knowns, unknowns

Identify the target quantity(ies)

Assemble appropriate tools (equations).

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STEP #3 Plan a Solution

Construct chain of equations leading from target quantity.

Check units of algebraic answer.

STEP #4 Execute the Plan

Use given values to calculate target quantity.

STEP #5 Evaluate the Solution

Is the answer properly stated?
Is the answer unreasonable?
Is the solution complete?

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Example problem

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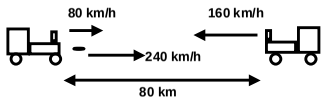
Step 1: Focus the problem

Visualize



Question:

What is distance insect travels in time it takes trains to collide?

Approach:

insect flies

Average speed = instantaneous speed

Trains have constant velocity

Average velocity = instantaneous velocity

Use definition of average speed.

Use definition of average velocity.

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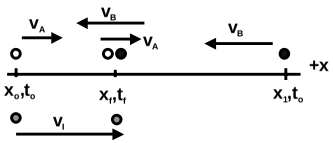
Step 2 : Describe the Physics

Motion Diagram:



$x_o = 0$ $t_o = 0$ $x_f = ?$ $t_f = ?$ $x_1 = 80$ km

$v_A = 80$ km/h $v_B = 160$ km/h $v_I = 240$ km/h

Target Quantity: d_I = distance insect flies in time $t_f - t_o$

Quantitative Relationships:

$s_I = \frac{d_I}{t_f - t_o}$ since insect speed is constant

$v_A = \frac{x_f - x_o}{t_f - t_o}$ since train A velocity is const.

$-v_B = \frac{x_f - x_1}{t_f - t_o}$ since train B velocity is const.

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Step 3: Plan the solution

unknowns

Find d_I d_I

$$s_I = \frac{d_I}{t_f - t_o}$$

$$s_I = \frac{d_I}{t_f} \quad [1] \qquad t_f$$

Find t_f

$$v_A = \frac{x_f - x_o}{t_f - t_o}$$

$$v_A = \frac{x_f}{t_f} \quad [2] \qquad x_f$$

Find x_f

$$-v_B = \frac{x_f - x_1}{t_f - t_o}$$

$$-v_B = \frac{x_f - x_1}{t_f} \quad [3]$$

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Step 4: Execute the Plan

Start from end of plan and work backwards to target

[3] $-v_B = \frac{x_f - x_1}{t_f}$ Find x_f

$$-v_B t_f + x_1 = x_f$$

[2] $v_A = \frac{x_f}{t_f}$ Find t_f

$$v_A = \frac{-v_B t_f + x_1}{t_f}$$

$$v_A t_f + v_B t_f = x_1$$

$$(v_A + v_B) t_f = x_1$$

$$t_f = \frac{x_1}{(v_A + v_B)}$$

[1] $s_I = \frac{d_I}{t_f}$ Find d_I

$$s_I = \frac{d_I}{\frac{x_1}{(v_A + v_B)}}$$

$$s_I \frac{x_1}{(v_A + v_B)} = d_I$$

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$$s_I \frac{x_1}{(v_A + v_B)} = d_I$$

check units:

$$(\text{km/h}) \frac{(\text{km})}{(\text{km/h} + \text{km/h})} = \text{km}$$

$$(240\ \text{km/h}) \frac{(80\ \text{km})}{(80\ \text{km/h} + 160\ \text{km/h})} = d_I$$

$$80\ \text{km} = d_I$$

Evaluate Solution:

Properly stated?

The distance is in km (ok units)

Unreasonable?

The distance is the same as initial separation of trains. Surprising but not an unreasonable distance.

Complete?

The distance was wanted (ok)

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Generalization

Does the insect's distance always equal the initial separation of the trains?

Suppose that the insect's speed were 120 km/hr

The answer is an ACCIDENT of the numbers not a general principle.

The insect's distance is NOT necessarily equal to the initial separation of the trains!

$s_I \frac{x_1}{(v_A + v_B)} = d_I$ Always gives insect's distance

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