CS 221 Lecture 8

Tuesday, 25 October 2011

Today's Agenda

1. Announcements
2. Graphing with Excel
3. Graphing with MATLAB
4. In-class Quiz

1. Announcements

- Second Lab Quiz: Thursday, 3 November
  - As always: if you will miss class for a legitimate reason, get in touch with your TA and Prof. Calvert as soon as possible
- Problem Set 3 out this week – due next week
  - Solving problems with MATLAB
  - Graphing with Excel and MATLAB

(The following slides are from the textbook Publisher.)

Types of Graphs, Plotting with Excel

Chapter 5
Plotting Data

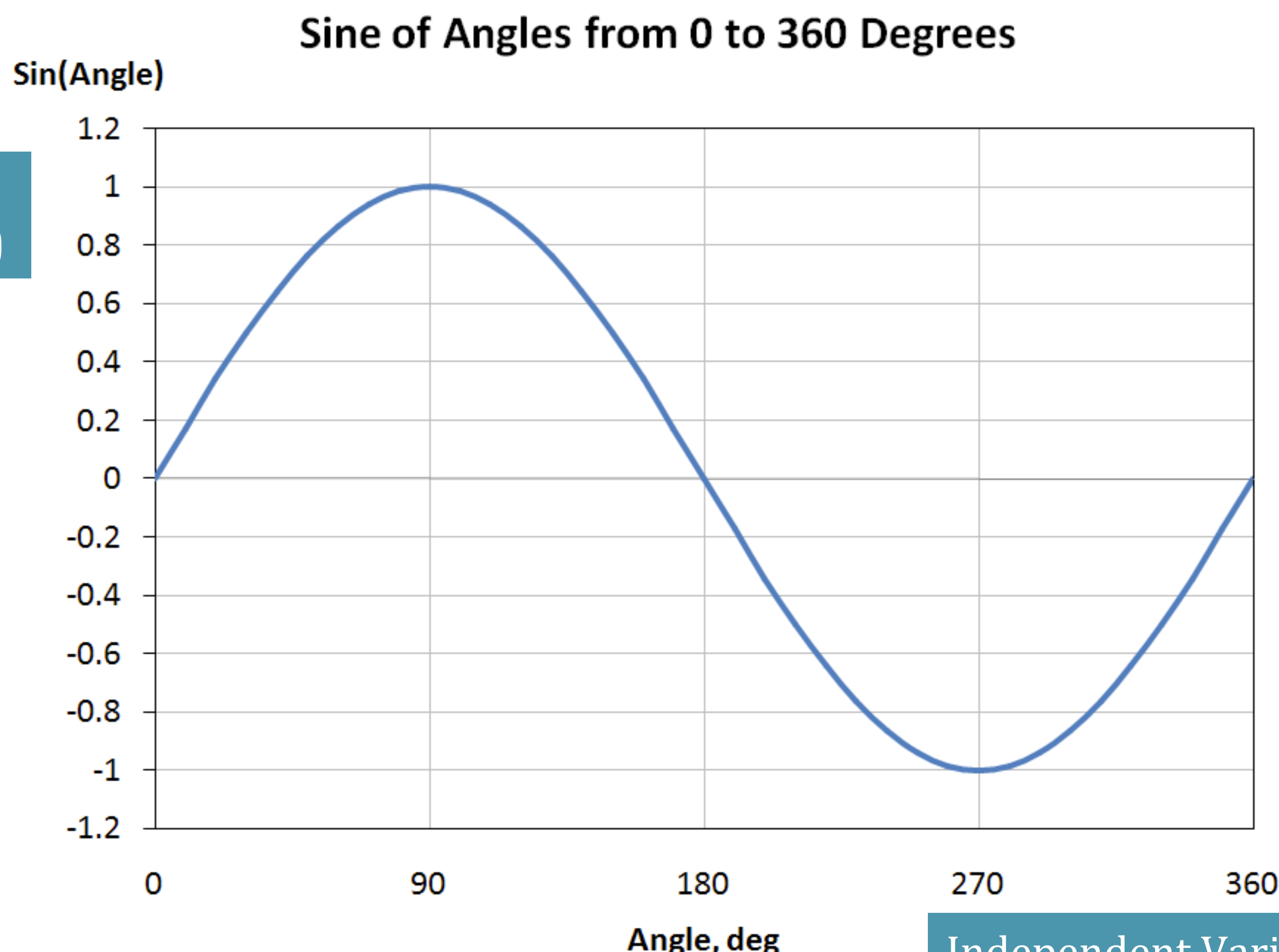
Introduction

- Creating graphs is an important communications skill for all engineers and students
- Graphs can:
  - Allow visualization of large data sets
  - Show trends in data
  - Show cause-and-effect relationships
- To begin, we will look at different types of graphs (note: graphs are called "Charts" in Excel, "Plots" in MATLAB)

XY (Scatter) Plots

- Most important type of graph used in engineering
- An independent variable (x) is plotted on the horizontal axis, and a dependent variable (y) is plotted on the vertical axis
- We say that we are plotting "y versus x"
- Often, more than one dependent variable are plotted on the same axes. This allows comparisons to be made

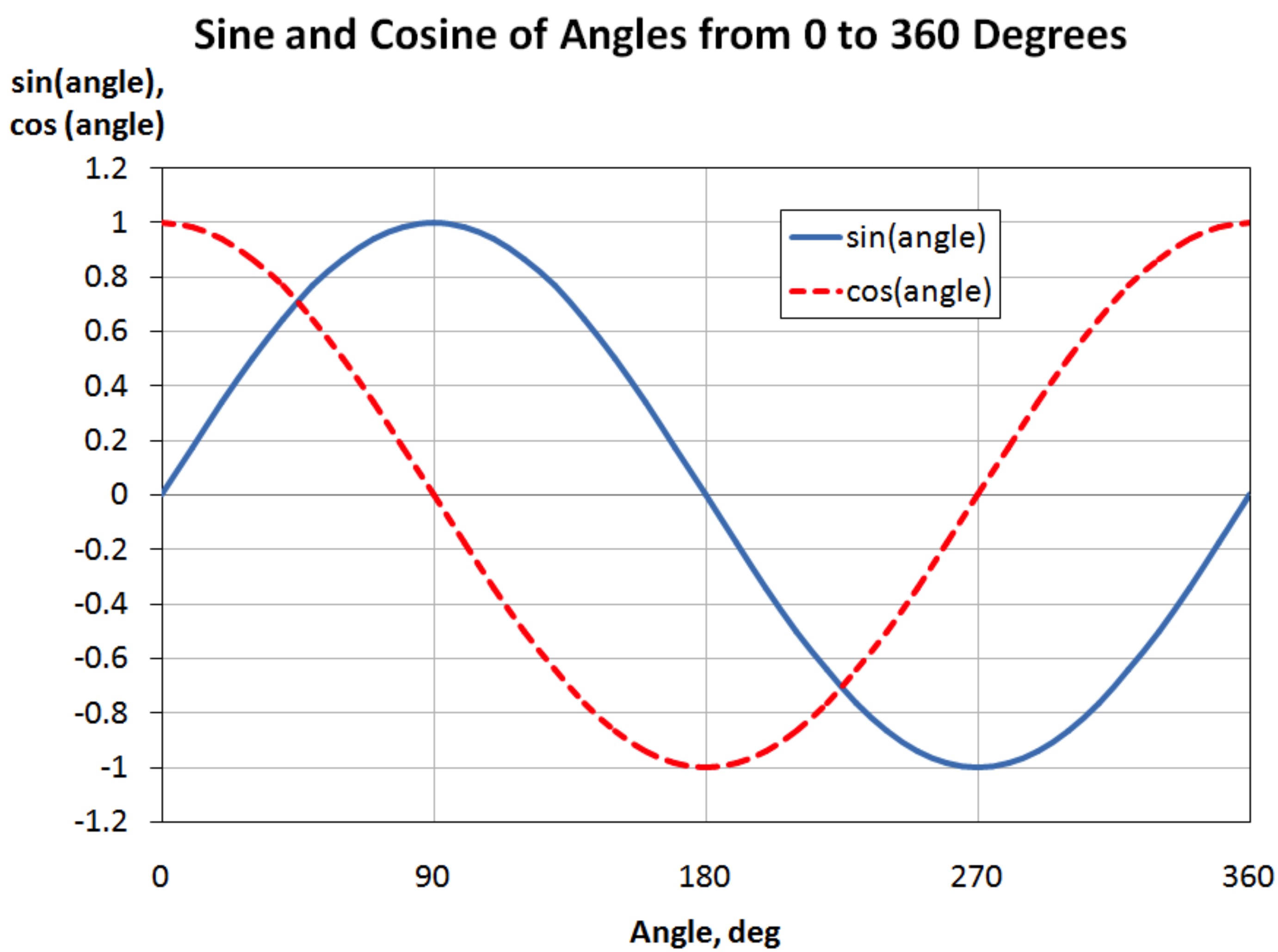
An XY (Scatter) Graph



Dependent Variable (y)

Independent Variable (x)

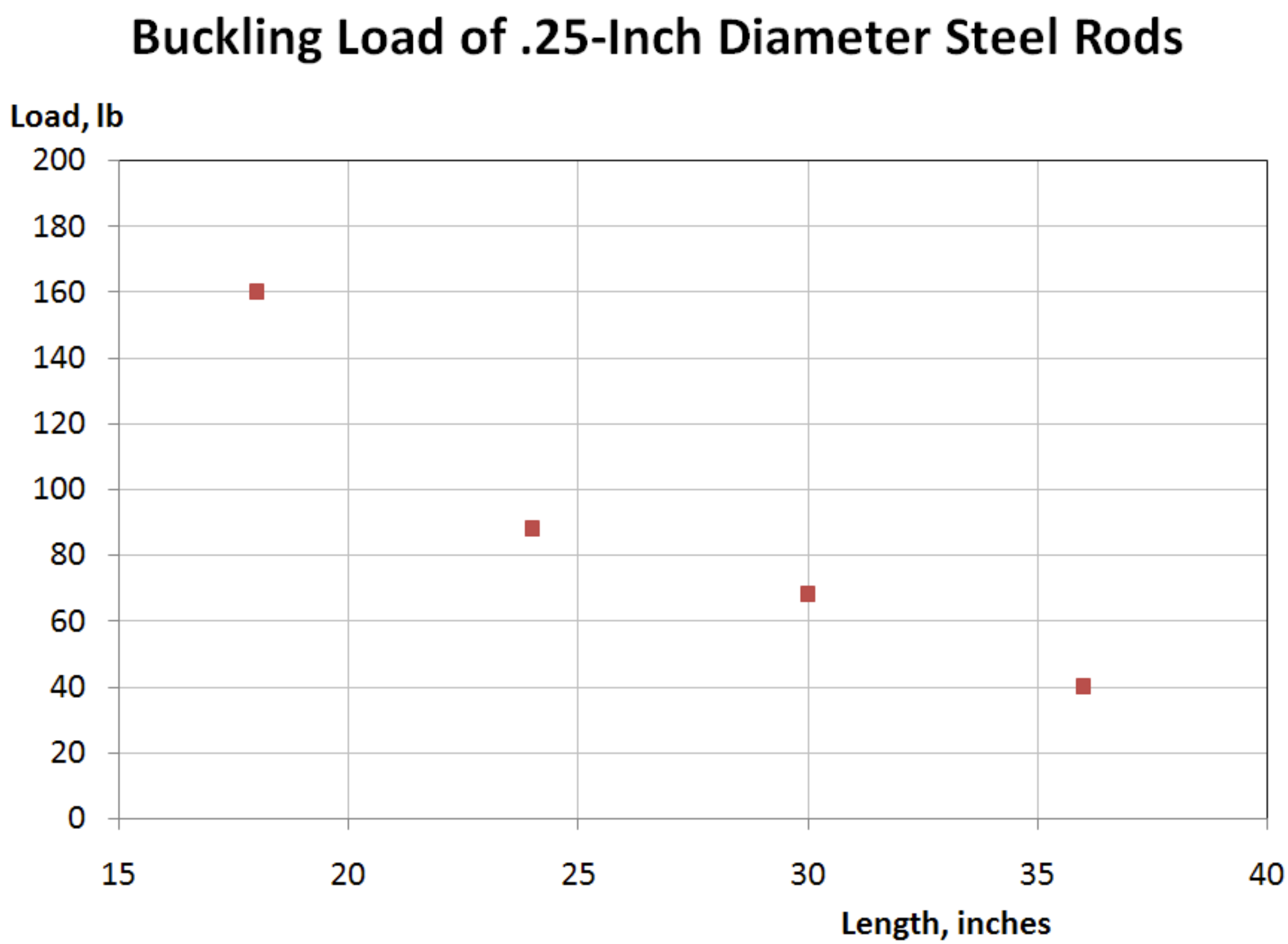
Two Curves on Same Axes Allow Comparisons



Use Lines and Markers on XY Graphs

- Equations should be plotted with smooth curves, without point markers – the points used to create the curve are not significant
- Measured data points *are* significant, and should be shown with markers (the name "scatter plot" comes from the scattered appearance of a large number of data points on a graph)

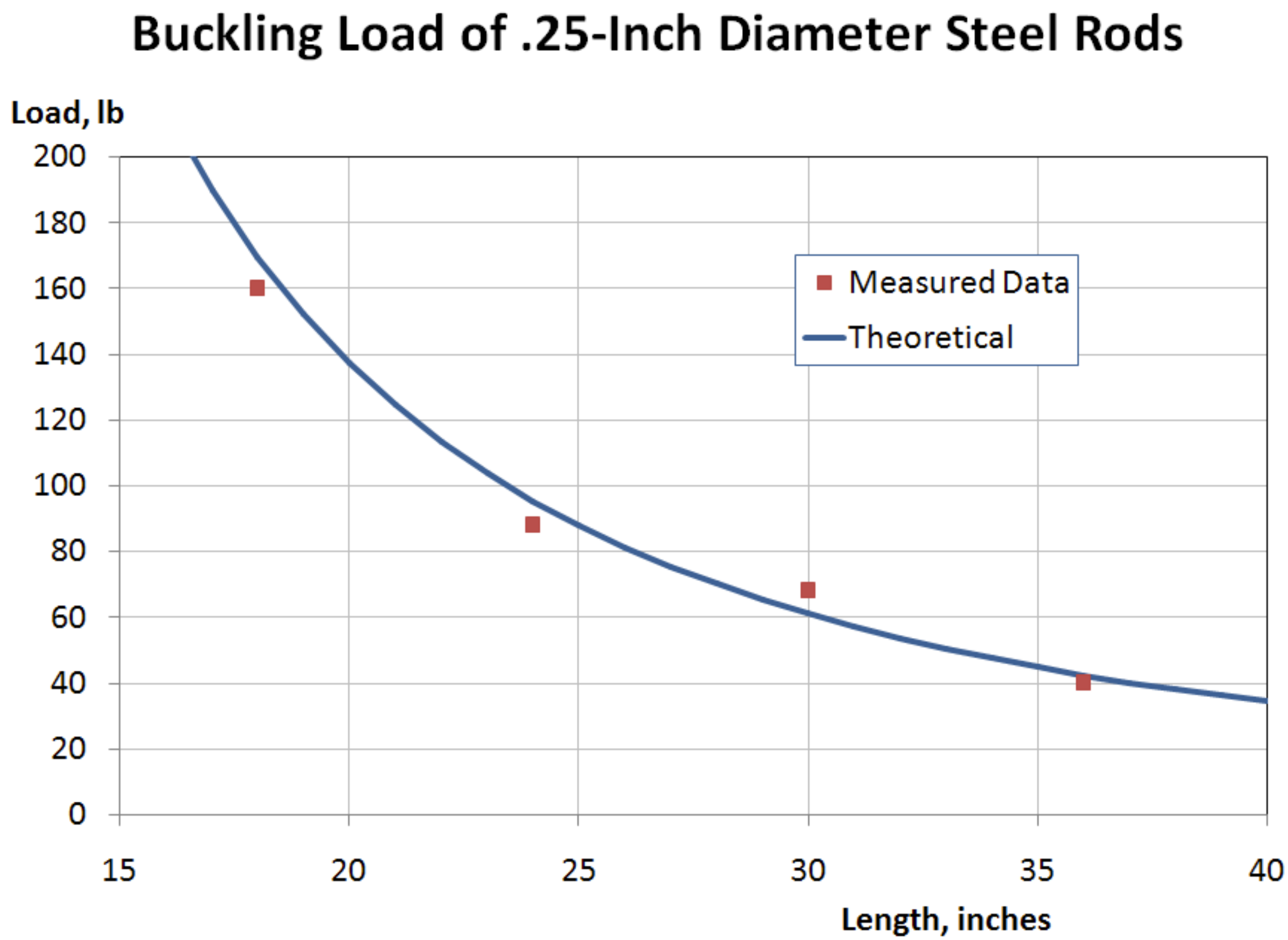
Measured Data Points



Lines and Markers on XY Graphs

- With measured data, adding a line is almost always done. The line is typically:
  - A *theory curve*, which shows how well the data points agree with theoretical values, or
  - A *fit line* (called a trend line in Excel), which is a curve based on the values of the data points. We will explore curve-fitting later in this chapter.

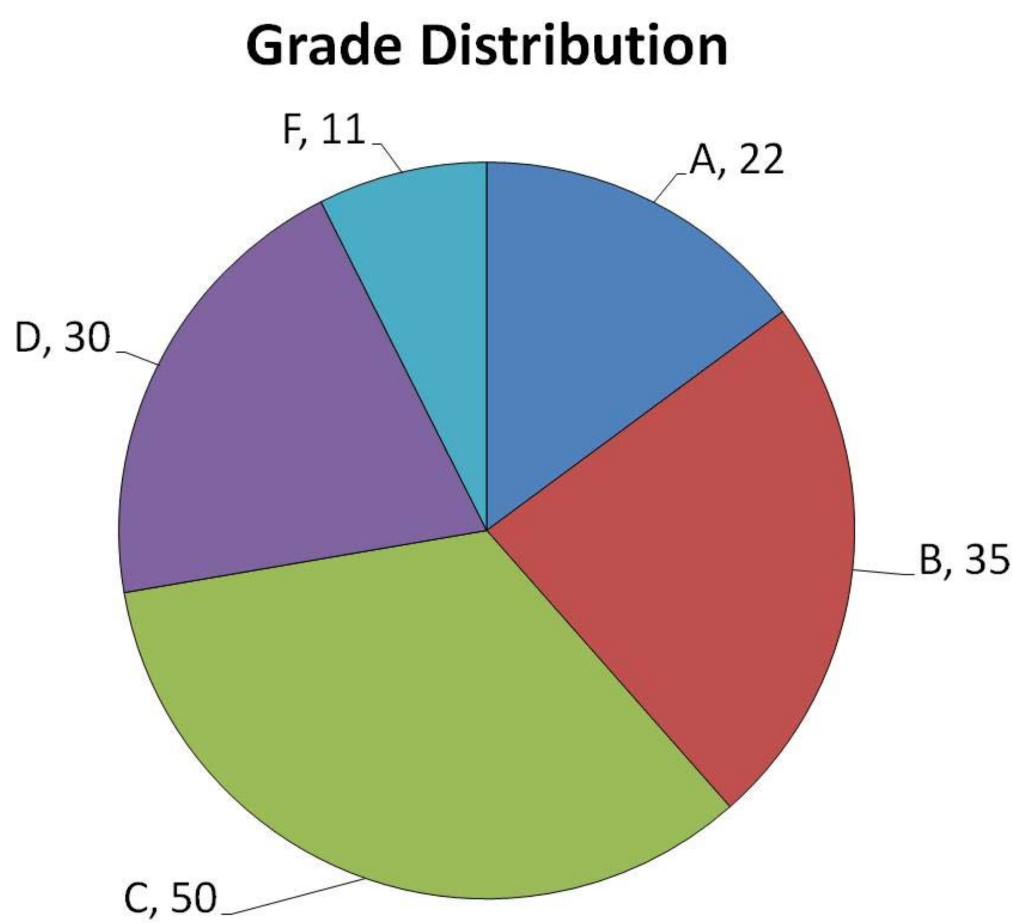
Measured Data with Theory Curve



Pie Charts

- Less typical than XY-charts in engineering
- Not a particularly efficient chart – data can easily be shown in a table
- Easy to understand, can be effective when presenting to a non-technical audience

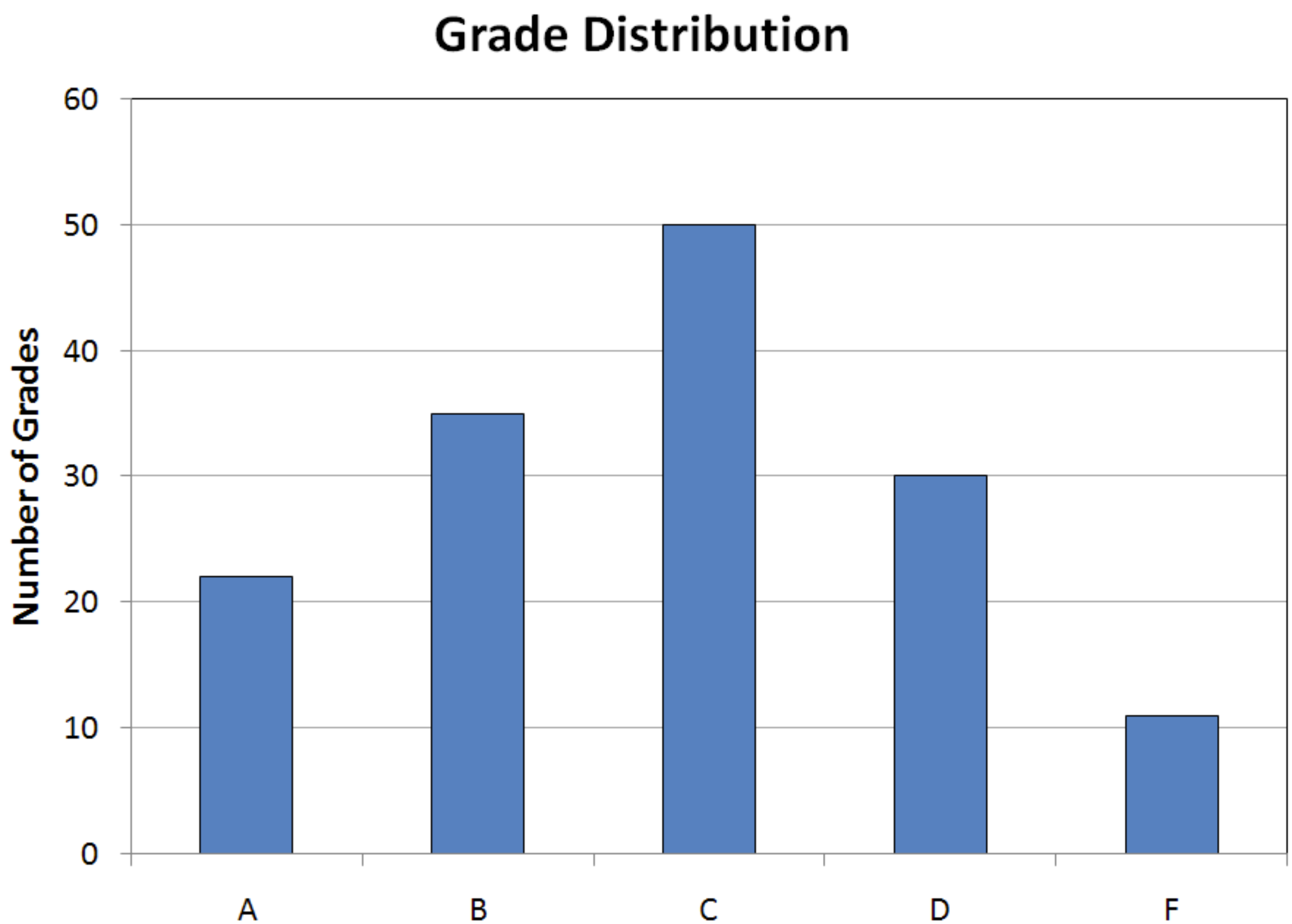
Pie Chart



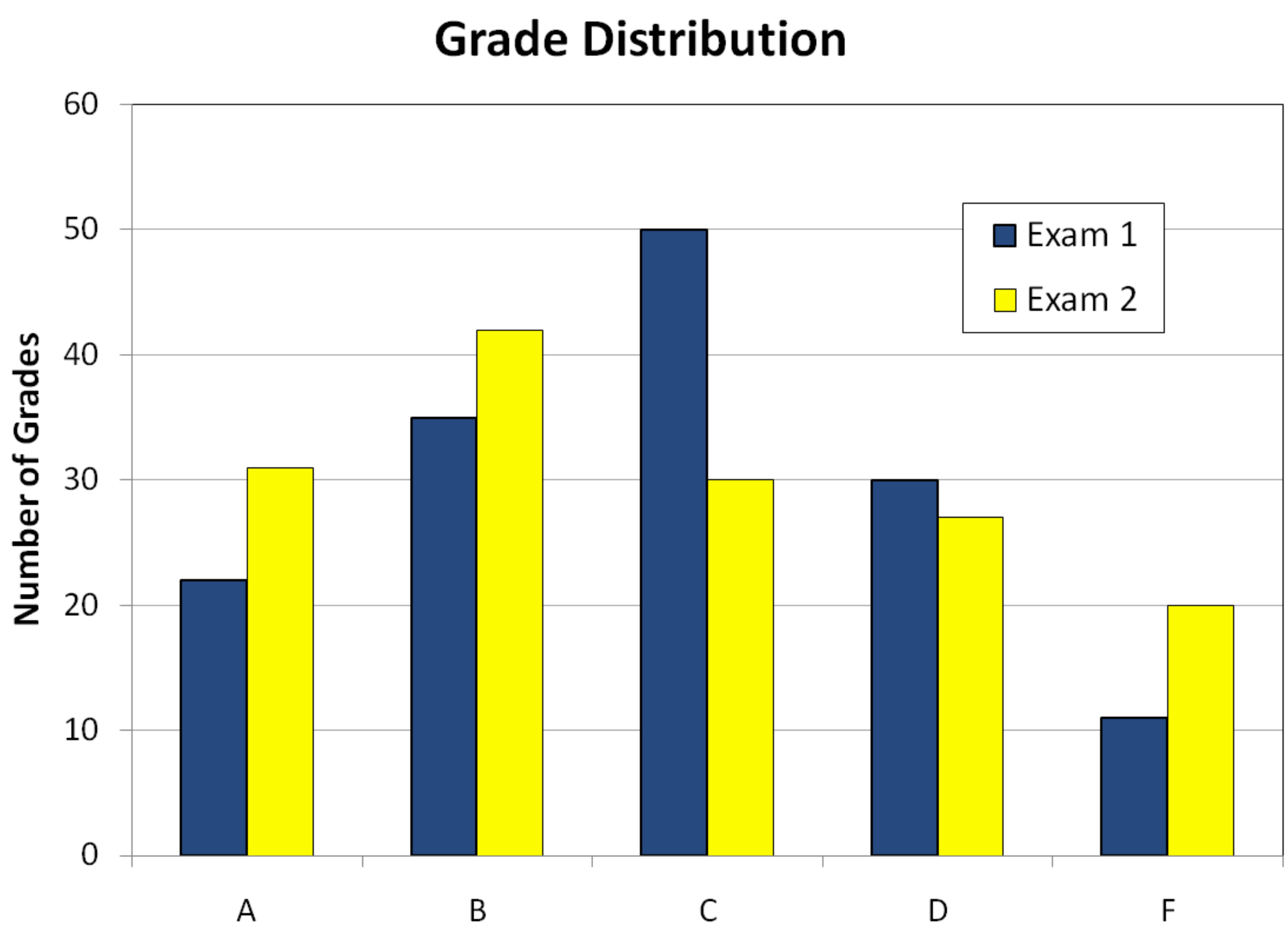
Bar Graph

- Data is represented by side-by-side bars, with bar heights proportional to data values
- Excel nomenclature: "Bar chart" applies when bars are horizontal, "Column chart" applies when bars are vertical
- More common usage: "Bar graph" is used to describe either orientation
- Bar graphs allow easy side-by-side comparisons between data sets

Bar Graph



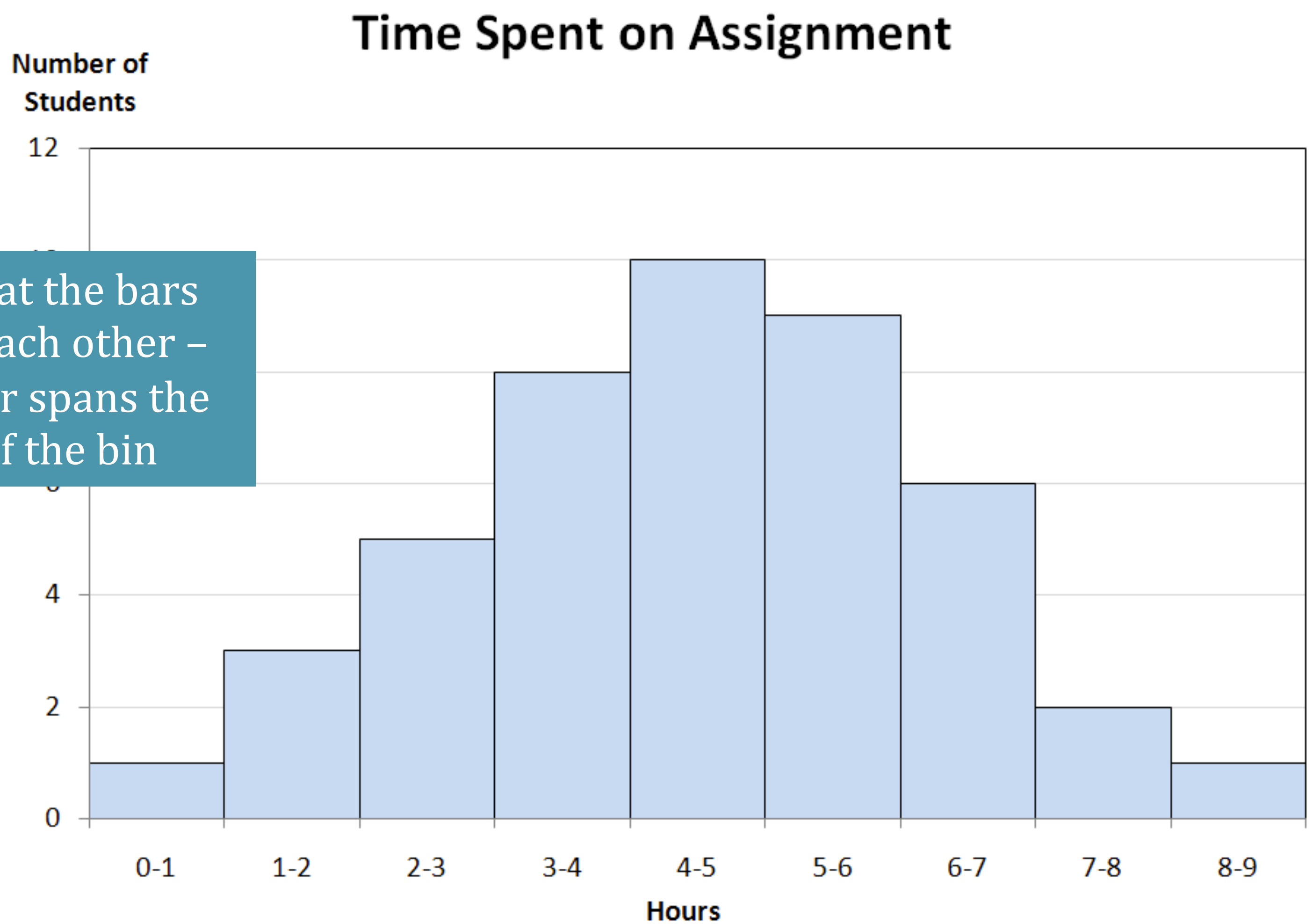
Bar Graph with Two Data Sets



Histogram

- Special type of bar graph
- Applied to *continuous* data sets that can be sorted into “bins”
- For example, if we ask students how much time they spent on a given assignment, we could group their answers into bins such as less than one hour, between one and two hours, between two and three hours, etc.
- When we create the bar graph, the bars should be as wide as the bins

Histogram

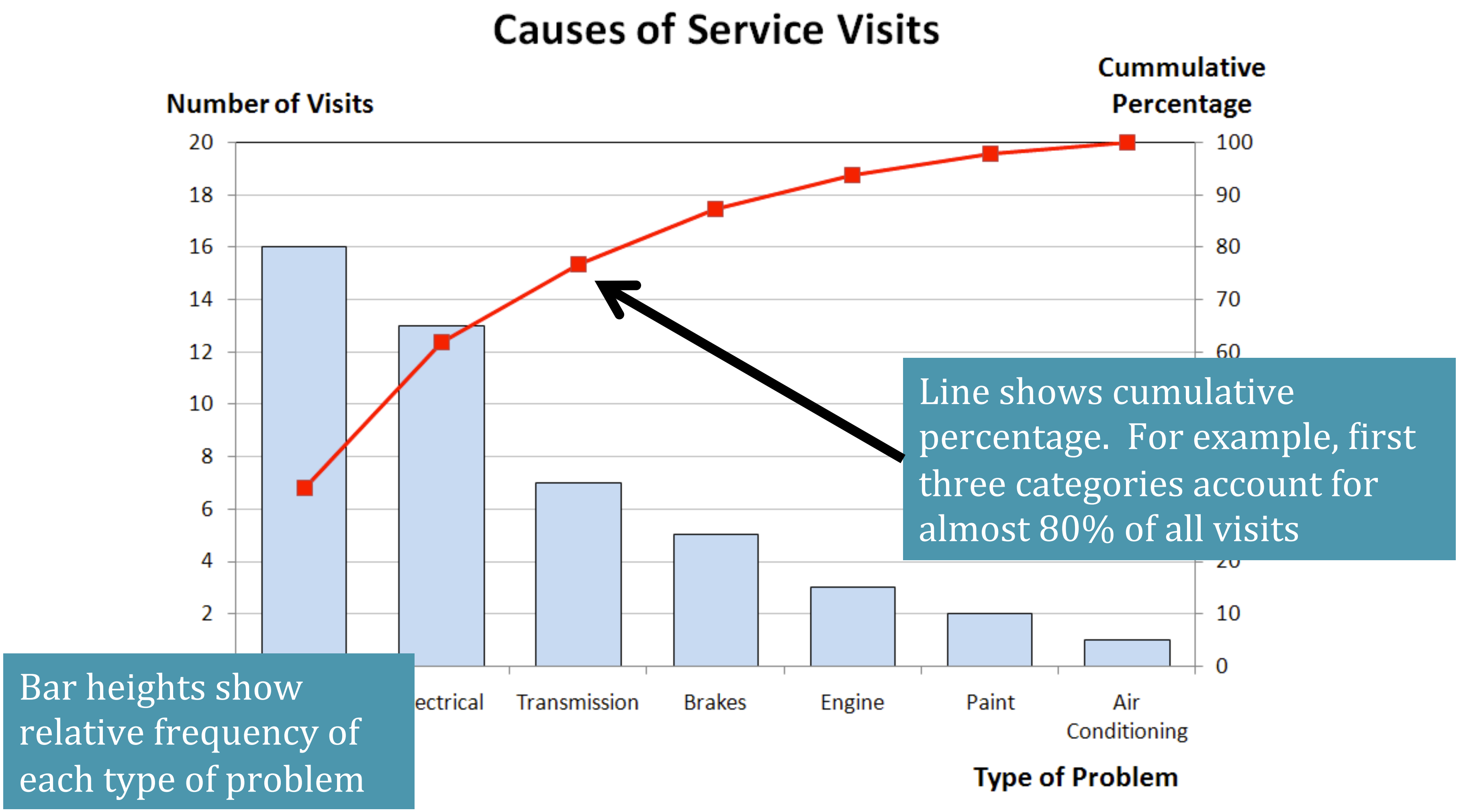


Note that the bars touch each other – each bar spans the width of the bin

Pareto Diagram

- Often used in quality control
- Used to present *categorical* data – for example, if we track the number of service visits to a car dealer, we might categorize them by the type of problem
- In the Pareto diagram, the categories are sorted by the number of data points in each, from high to low
- A bar graph shows the relative frequency of each category
- A line shows the cumulative percentage for each category

Pareto Diagram

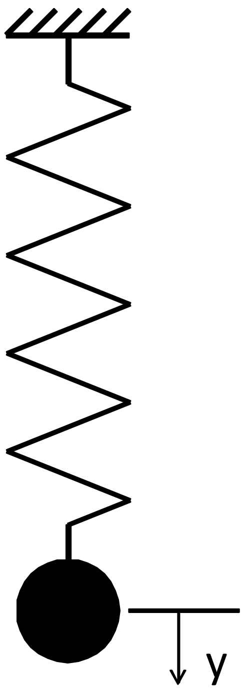


XY Graphing Tutorial

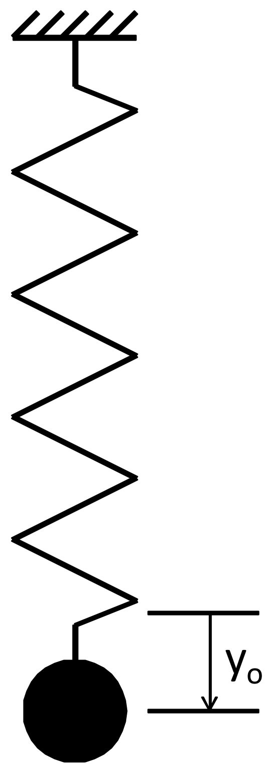
- Graph response of spring-mass-damper system
- Before beginning this exercise, some background is helpful

Spring-Mass System

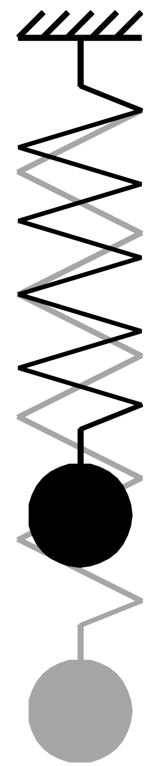
This mass is hanging from a spring, at rest. The displacement, *y*, is zero at this position



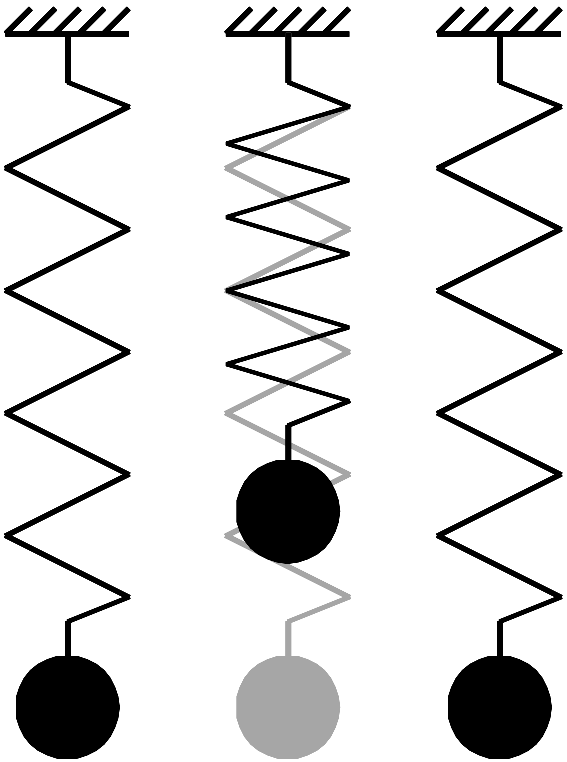
At time *t* = 0, the mass is pulled to the initial displacement y_o and released



The mass will then *oscillate* up and down



Spring-Mass System

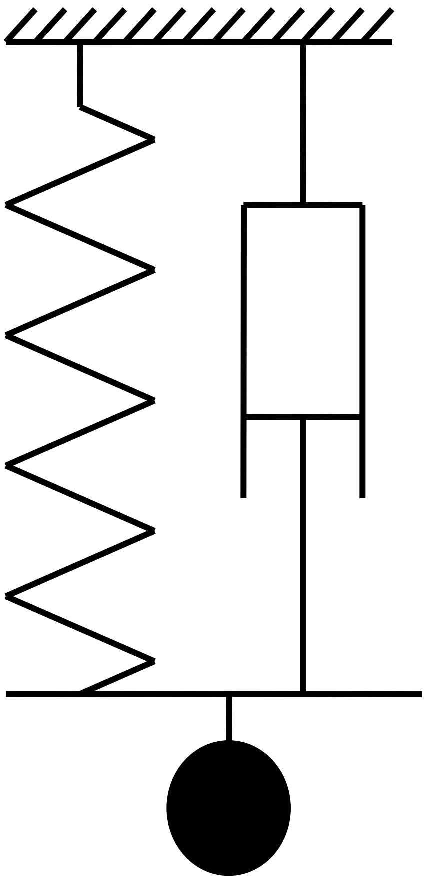


The time required for the mass to make one complete cycle is called the *period* of oscillation

The inverse of the period is the *natural frequency* of the system, in units of cycles per time or radians per time. The natural frequency is a function of the spring stiffness and the mass

Theoretically, the mass will continue to oscillate indefinitely, since there are no forces to stop it

Spring-Mass-Damper System

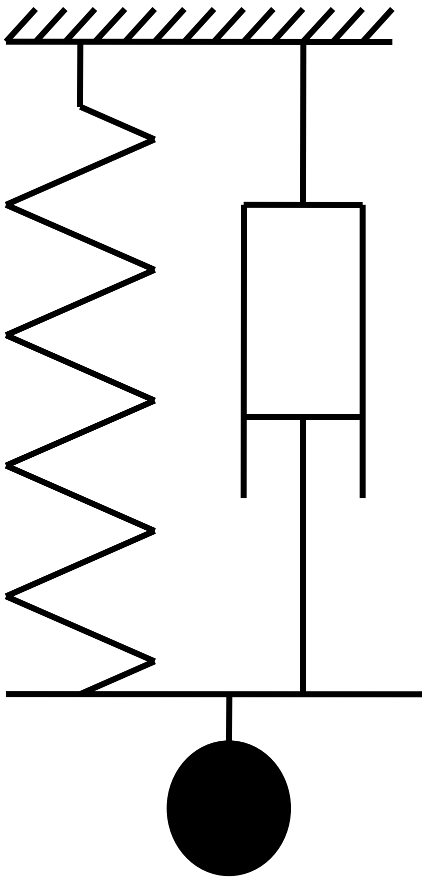


In reality, we know that the oscillations will get smaller with time, even if only due to internal forces in the spring

The presence of a *damper* will cause the oscillations to get smaller at a much faster rate

Examples of dampers:
Shock absorbers on cars, storm door closers

Spring-Mass-Damper System



The *damping coefficient* is a measure of the effectiveness of the damper

If the damping coefficient is less than one, we say the system is *under damped*, and will oscillate

If the damping coefficient is one, then the system is *critically damped* and the mass will settle back to its original position without oscillating

Spring-Mass-Damper System

In future courses, you will learn to formulate and solve the differential equation defining the system's response

For the under damped system, the solution is:

$$y = \left[y_0 cos\omega_D t + \frac{y_0 \xi \omega}{\omega_D} sin\omega_D t \right] e^{-\xi\omega t} \qquad (5.1)$$

where: y = the displacement of the mass relative to its original position
y_o = the initial displacement (the displacement at time t = 0)
ω = the natural frequency of the system, a measure of how fast the system will oscillate freely
ξ = the damping coefficient, a value between zero and one
t = time

and ω_D = the damped frequency, which is calculated as:

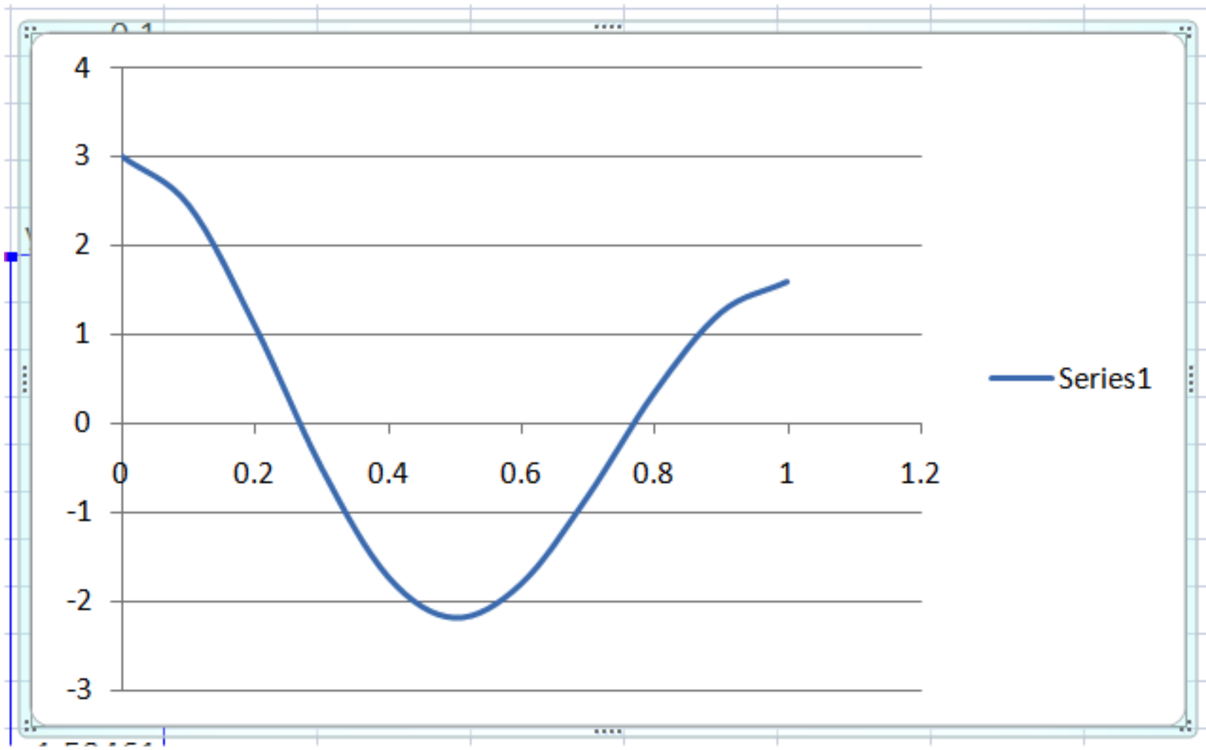
$$\omega_D = \omega\sqrt{1-\xi^2} \qquad (5.2)$$

Graphing Response

- Given values for natural frequency, damping coefficient, and initial displacement, graph displacement y versus time t
- What time steps should you use? What time domain (i.e., interval of time) should be shown?
- Trial and error: Need small enough time steps to produce a smooth curve and pick up all oscillations. Need to pick a time domain sufficient to show response adequately

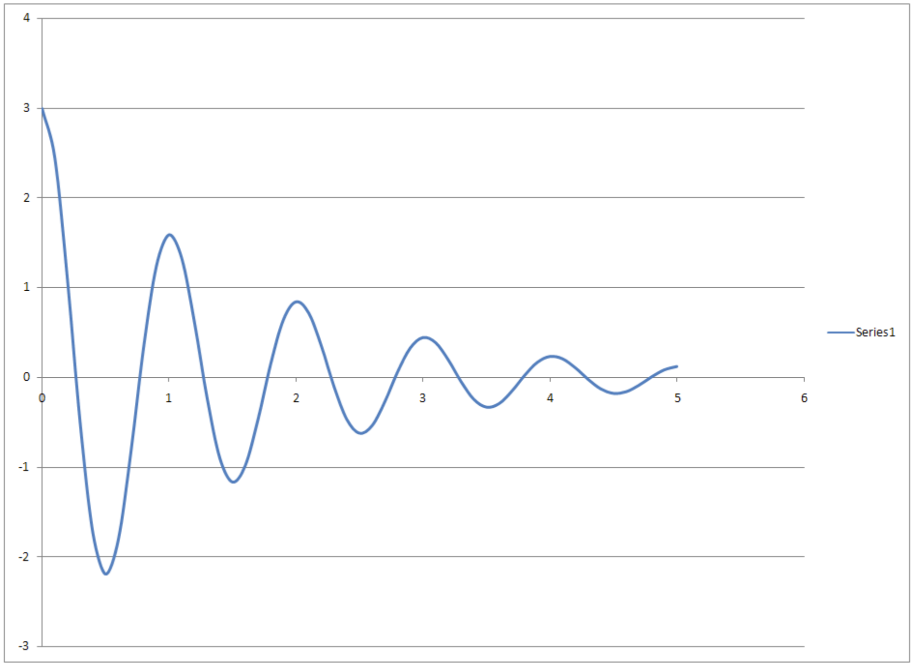
Graphing Response

- Time domain = 0 to 1 seconds
- Can't tell much – need to increase time



Graphing Response

- Time domain = 0 to 5 seconds
- Much better – shows that period is about 1 second; oscilations have been mostly damped out by 5 seconds
- Now we need to make it look nice



Finished Graph