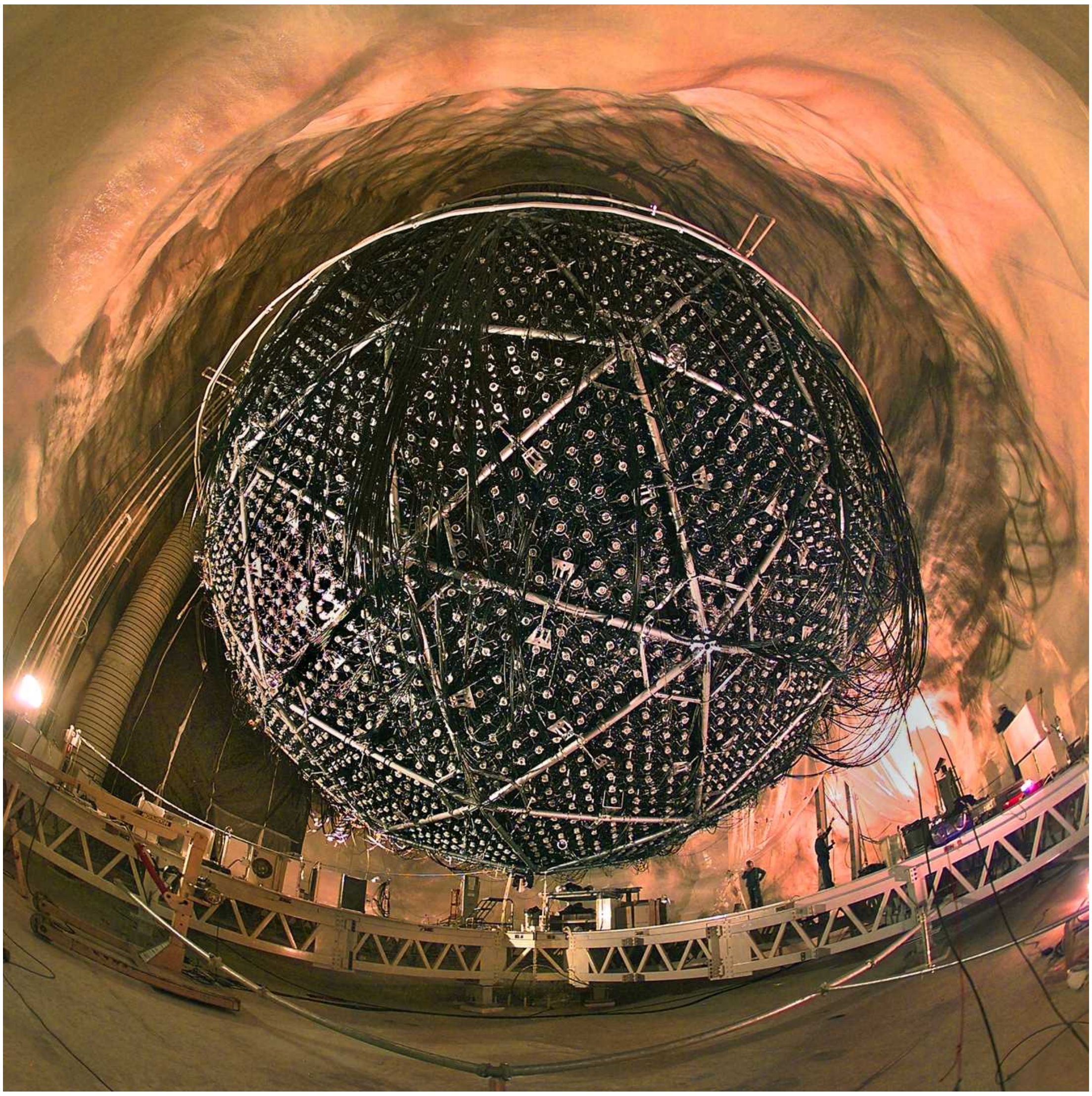
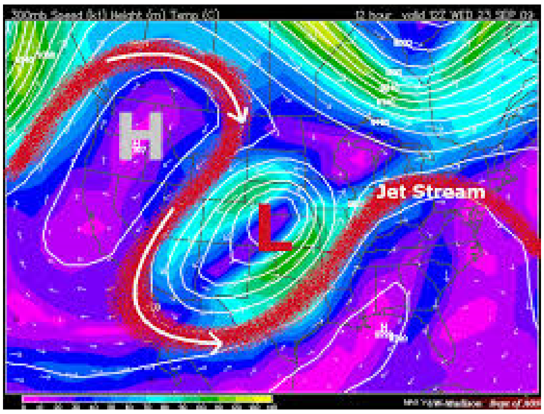
Modeling Physics

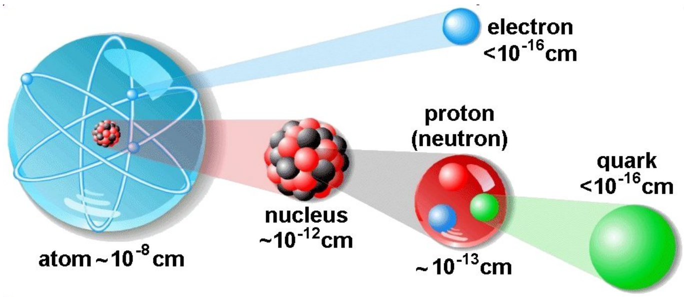
- Modeling in science and mathematics is an extremely important for:
  - > Predictions (stocks, weather, hospital patients).
  - > Determining the structure of objects we cannot sense (interior of Earth or stars, ultrasonic sounds, atoms).
  - > Analyze changes in variables.
- Models are created through graphing collected or mathematically generated data.
- In any field of science there are people who work towards modeling the nature - both the Earth and the entire universe.
- Models are always changed and updated to reflect new data, or new discoveries.
  - > Standard Solar Model, for example, was greatly fine-tuned with data from the Sudbury neutrino observatory.

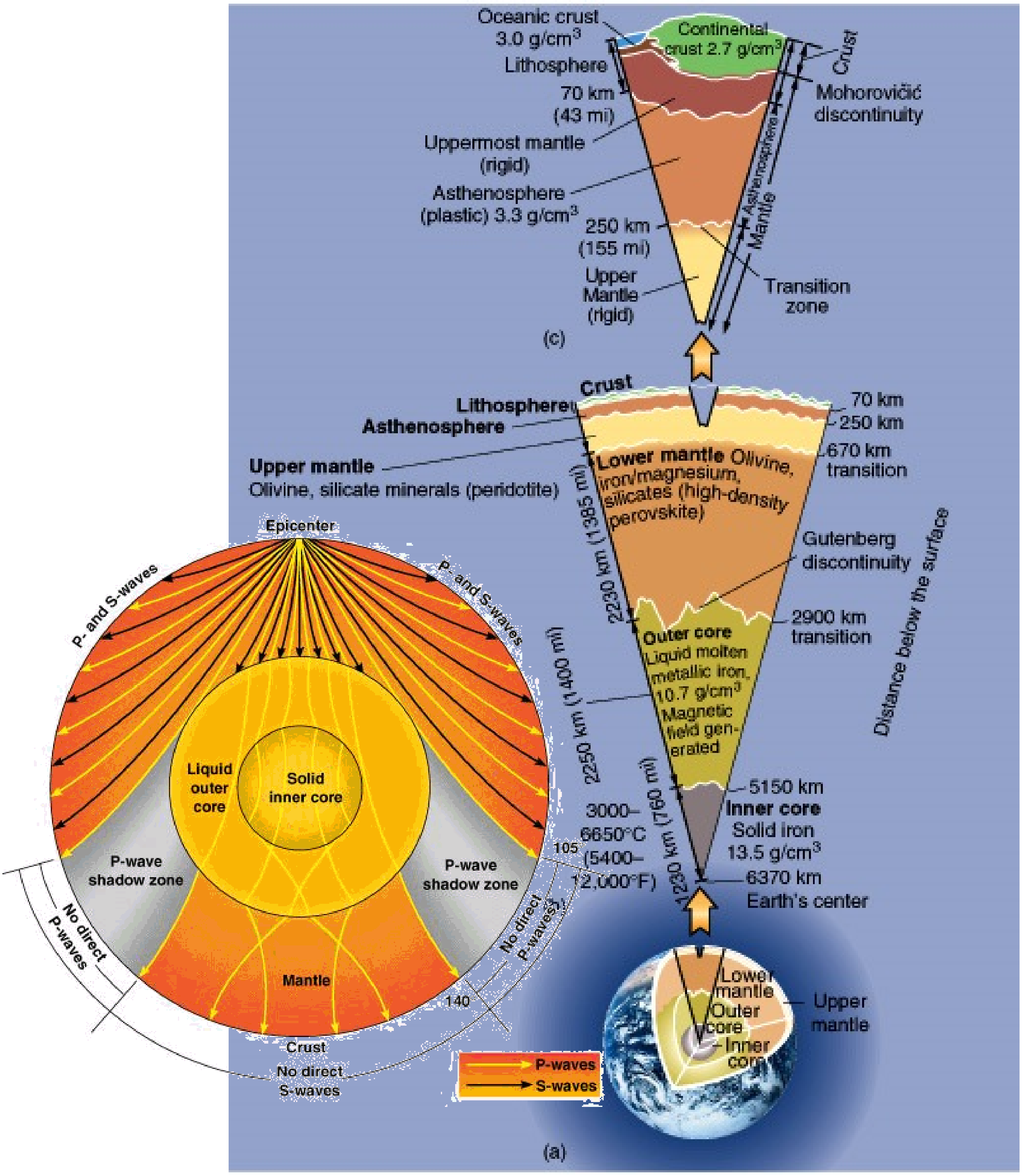


March 10, 2014

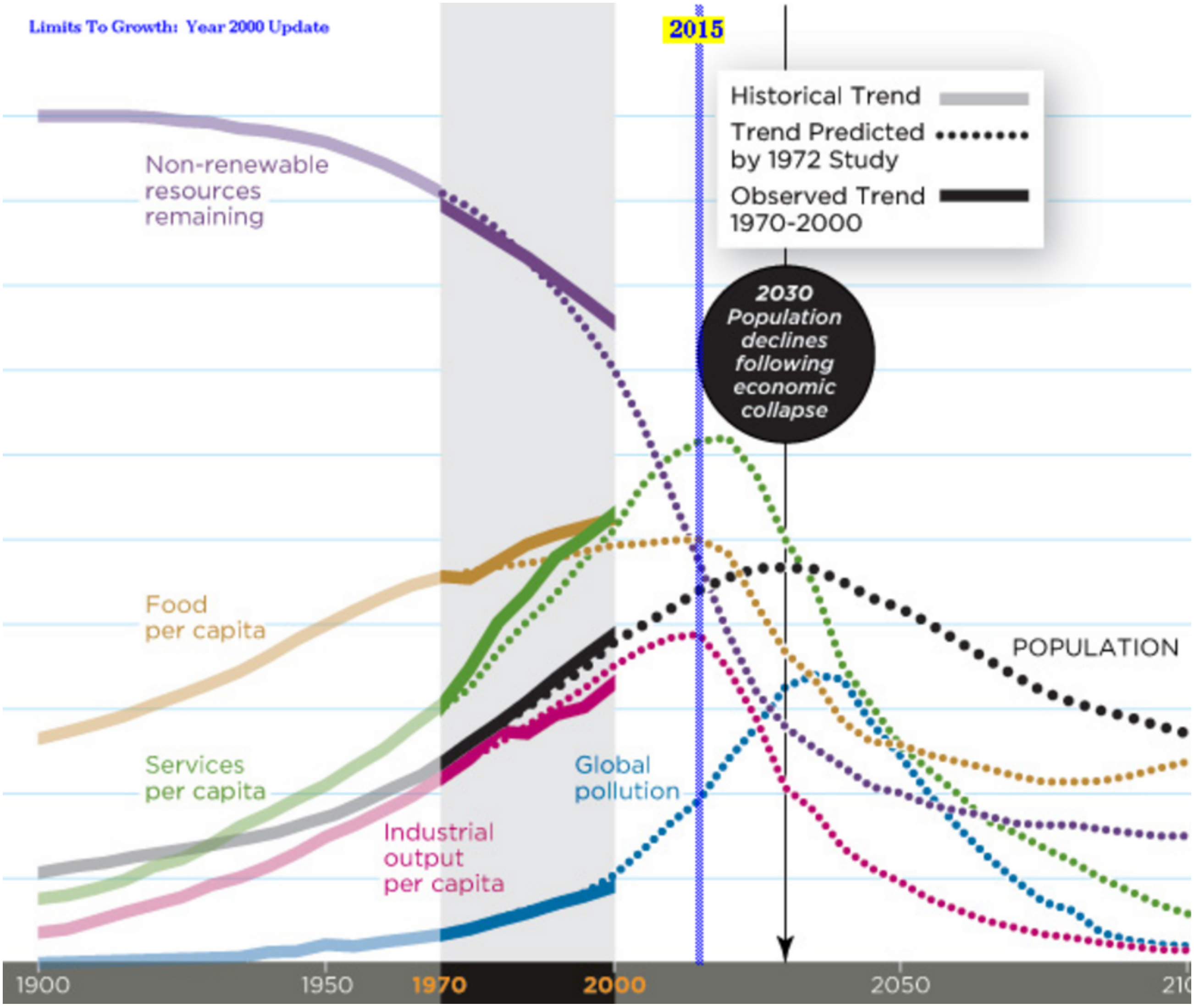
Modeling Physics - Examples



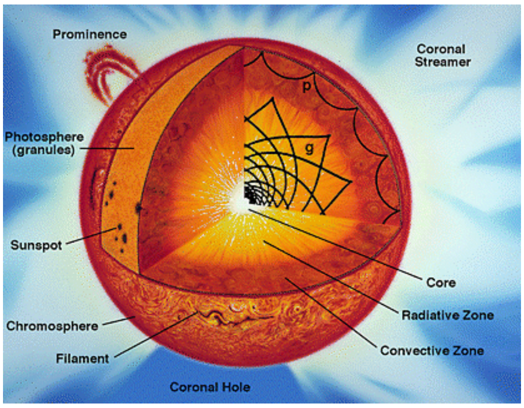




Modeling Physics - Examples



Modeling Physics - Examples

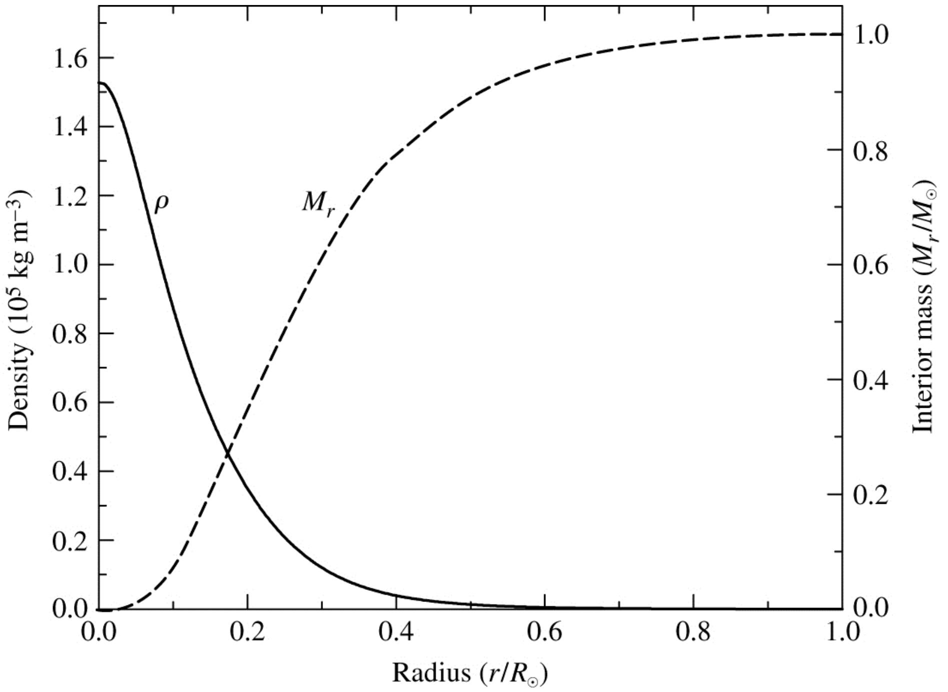


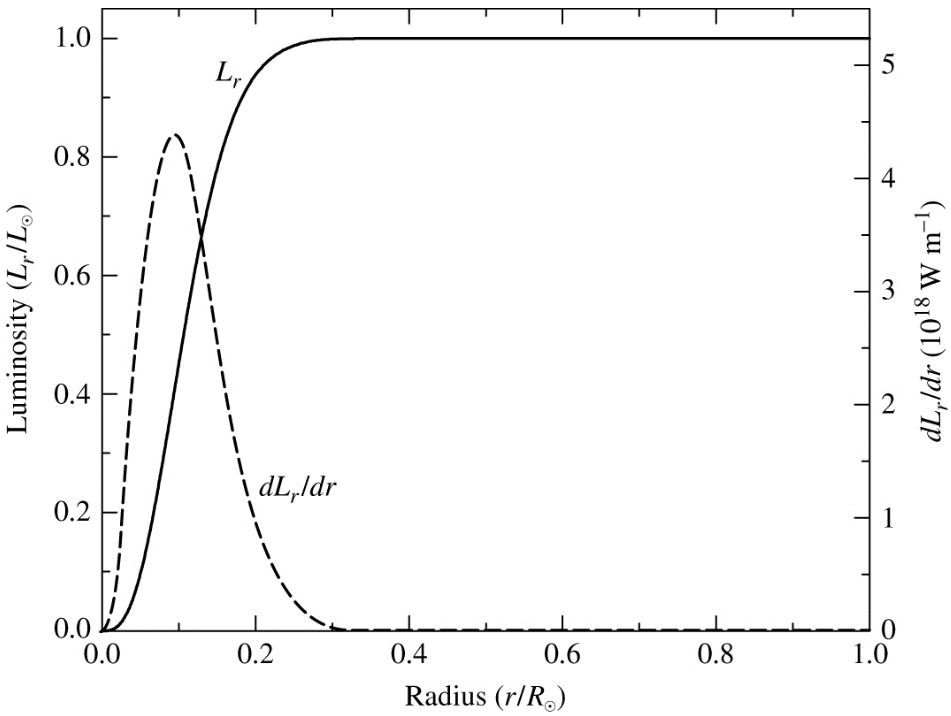
$$\frac{dP}{dr} = -\frac{GM\rho}{r^2}$$

$$\frac{dP}{dr} = -\frac{4\pi G\rho^2 r}{3}$$

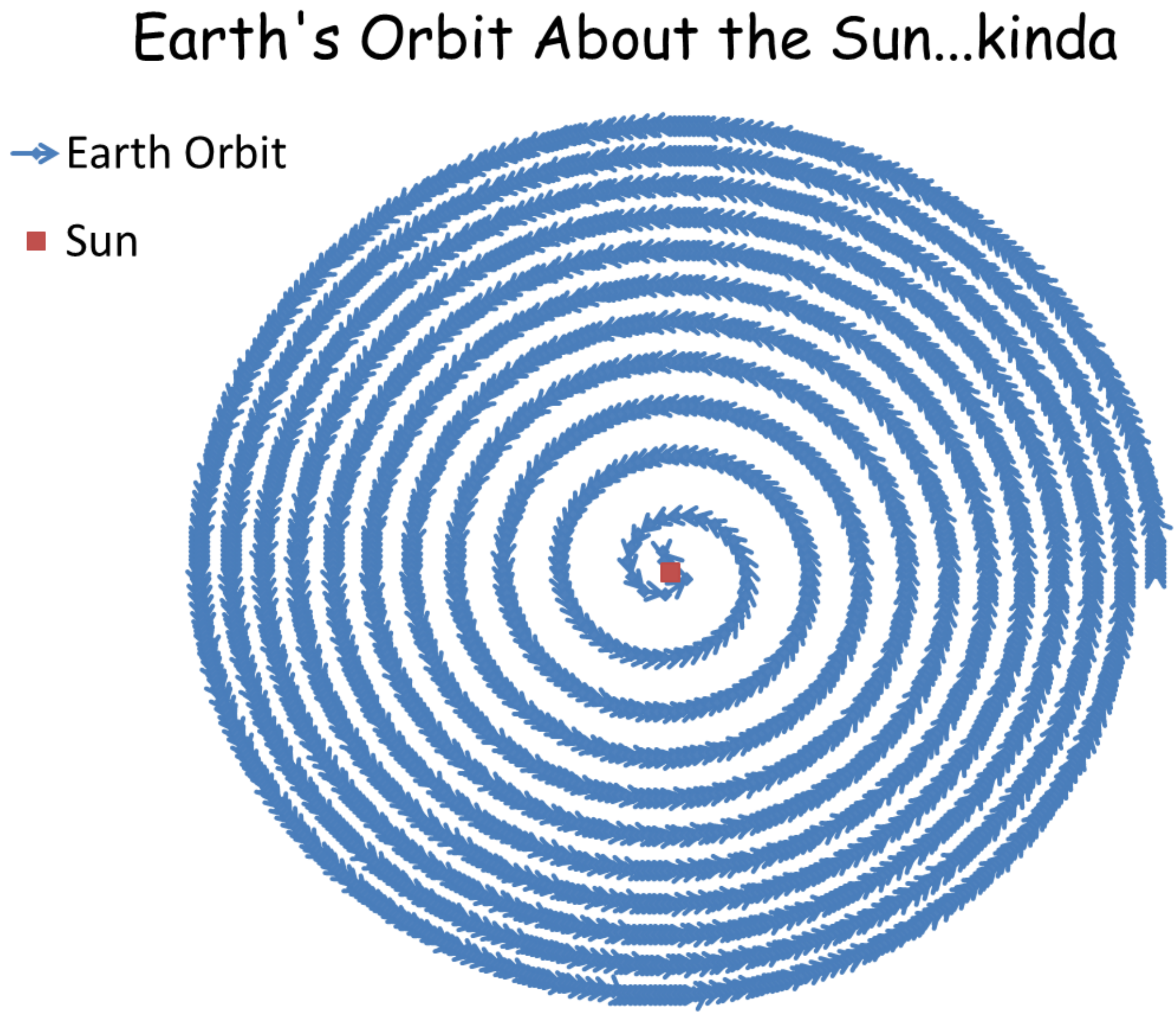
$$P(r) = \int_r^R \frac{4\pi G\rho^2 r}{3} dr$$

$$P(r) = \frac{2\pi G\rho^2}{3}(R^2 - r^2)$$



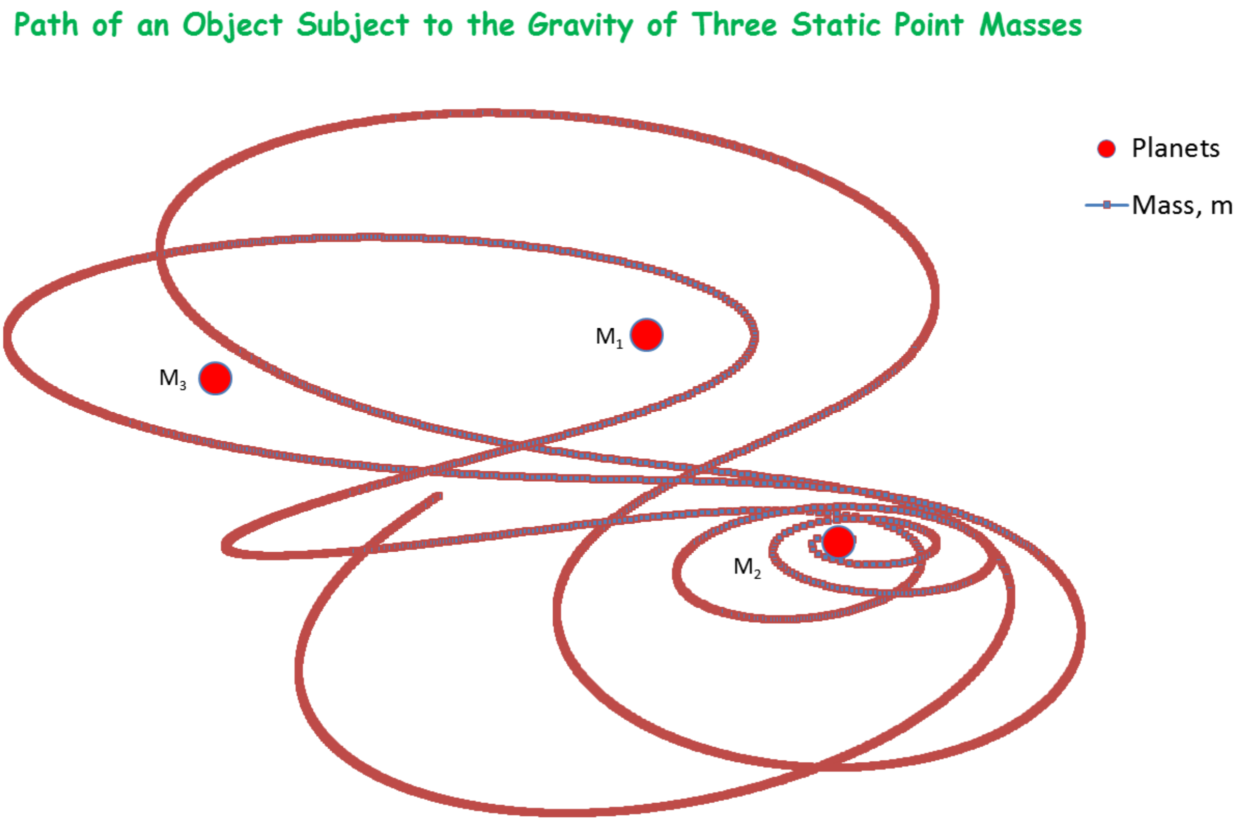


Modeling Physics



Simulated 5.3 years by calculating the position of the earth every 13.9 hours (3344 data points).

Modeling Physics



Unrealistic for objects in space (scale is not accurate). 3496 data points with dynamic variables calculated every 0.6 seconds givning a time frame of 35 minutes.

Graphical Modeling of Motion

- Most of the time when solving a physics equation we only calculate what is happening to an object at that very specific instant in time.
- For the next week or so you will learn how to model an object's motion over a period of time. For this we will use Excel to generate data at specific time intervals.
  - > You will learn how to create and manage basic formula's and scatter plots in Excel.
  - > Save and back up your work frequently. We will come back to modeling in future units.

SAVE

ctrl+s

Set Up - Excel Tutorial

- Open Excel
- Type initial parameters and its value in the adjacent cell.

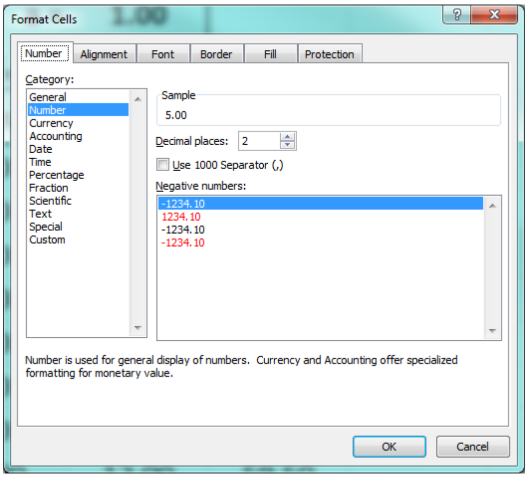
	A	B	C	D	E
1	Initial Parameters	Magnitude (m/s)	Horizontal Direction	Angle (°)	Vertical Diretion
2	v_o =	15.00	E	30.0	N
3	a =	6.50	W	60.0	S
4	t_{step} =	0.10			

Initial Parameters

Values

SAVE *ctrl+s*

- t_{step} is the "time step" - this is the time interval for calculating the object's instantaneous motion. This is the most important parameter in our modeling.
- Keep your work organized with good formatting. Found under the "font" and alignment sub-tabs.
  > Note the use of subscripts (select text then right-click, choose format cells, check the subscript box under the "font" tab).
  > Cells with parameter symbols are right-aligned.
  > Values are centered and display two decimal places (select cells then right-click, format cells, find the decimal places under the "number" tab).



- We can only quantitatively analyze physics in one dimension at a time. Create headings along the top row for the components of the initial parameters.

	F	G
1	Horizontal Component	Vertical Component

- West and South components must calculate to be a negative. We us an Excel version of an "if statement".
- In cell F2 carefully type (not case sensitive):

=IF(C2="E",B2*COS(D2*Pi()/180),-(B2*COS(D2*Pi()/180)))

Condition — Output if true — Output if false

- Fill in the formula for the vertical component.
- Copy the formulas down one row.
  > Select the formulas to copy, place mouse over bottom rigt corner until you see a small cross, drag down one (or as many as needed) row.

- Create column headings for the data that will be generated.
  - > We will assume all values are in proper SI base units.
  - > When labeling graphs we must include units.

5	t (s)	v_{fE}	v_{fN}	v_f (m/s)	Horizontal Direction	Angle (°)	Vertical Direction

- Below each heading enter the appropriate formula.
  - > We will start all of our modeling at time 0.0, type 0.0 in cell A6.
  - > In Excel the cell address takes the place of the variables used in formulas.

For example, in B6 type: =$F$2+$F$3*A6

$v_{oE} + a_E t$

SAVE

ctrl+s

- The "**=**" sign is very important, it tells Excel we are inputting a formula and not just text. The "**$**" tells Excel to always read the value of this cell when copying the formula.
- Type the appropriate formula in C6 and D6 to calculate V_{fN} and the magnitude v_f, respectively.
- Type formulas in E6, F6, and G6 for horizontal direction, angle (use "ATAN" for inverse tangent), and vertical direction, respectively.
- The first row of data should read the same as our initial parameters:

	t (s)	v_{fE}	v_{fN}	v_f (m/s)	Horizontal Direction	Angle (°)	Vertical Direction
5							
6	0.00	12.99	7.50	15.00	E	30.0	N

- This is where the power of Excel kicks in. By selecting the cells of which we want more data, we can copy the forumlas down the columns.
  - > Do this for one row:

	t (s)	v_{fE}	v_{fN}	v_f (m/s)	Horizontal Direction	Angle (°)	Vertical Direction
5							
6	0.00	12.99	7.50	15.00	E	30.0	N
7	1.00	9.74	1.87	9.92	E	10.9	N

- Time has auto-incremented by 1.00 second! We do not want this.
- Time must increment by our desired time-step. In A7 type:

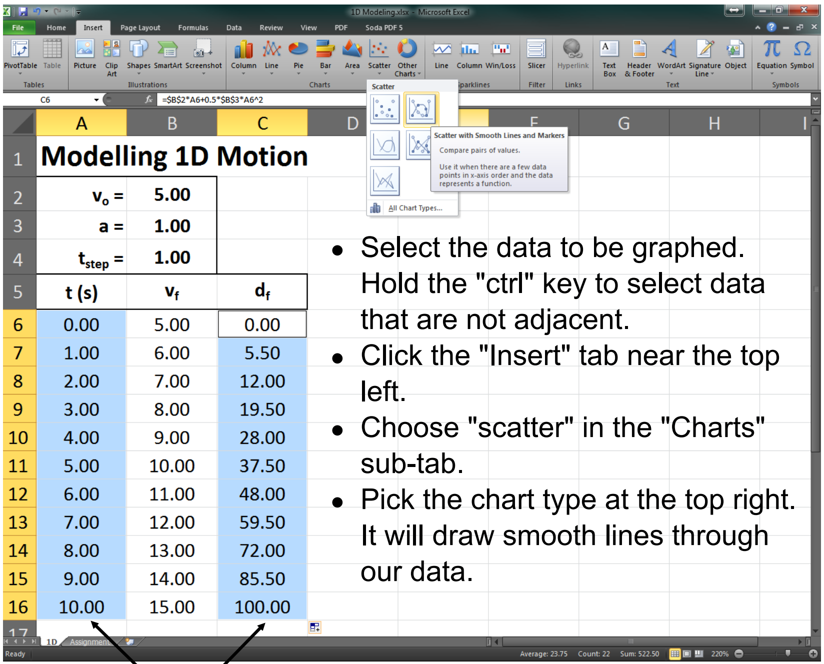
=A6+$B$4

(A6: previous time; $B$4: t_{step})

	t (s)	v_{fE}	v_{fN}	v_f (m/s)	Horizontal Direction	Angle (°)	Vertical Direction
5							
6	0.00	12.99	7.50	15.00	E	30.0	N
7	0.10	12.67	6.94	14.44	E	28.7	N

- Copy the formulas in row 7 until a time of 5.00 seconds is reached and review how the variables have changed with time.
- Explore what happens when you change the initial parameters, everything is automatically recalculated!
  - > Remember, the magnitudes of initial parameters are always positive. Direction is controlled with East, West, North, and South options.

Graphing Scatter Plot Data in Excel



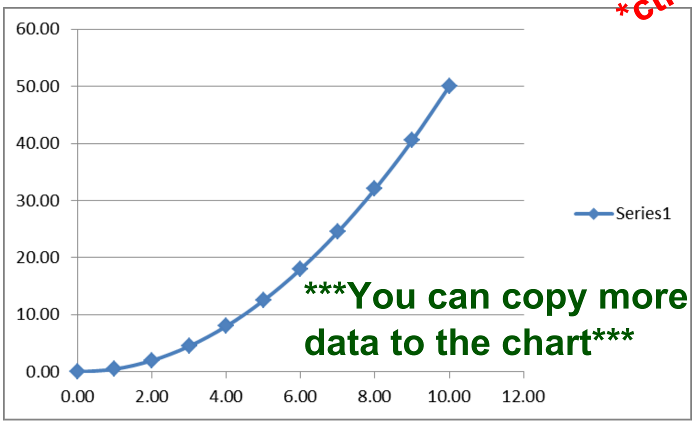
	A	B	C
1	Modelling 1D Motion		
2	v_o =	5.00	
3	a =	1.00	
4	t_{step} =	1.00	
5	t (s)	v_f	d_f
6	0.00	5.00	0.00
7	1.00	6.00	5.50
8	2.00	7.00	12.00
9	3.00	8.00	19.50
10	4.00	9.00	28.00
11	5.00	10.00	37.50
12	6.00	11.00	48.00
13	7.00	12.00	59.50
14	8.00	13.00	72.00
15	9.00	14.00	85.50
16	10.00	15.00	100.00

- Select the data to be graphed. Hold the "ctrl" key to select data that are not adjacent.
- Click the "Insert" tab near the top left.
- Choose "scatter" in the "Charts" sub-tab.
- Pick the chart type at the top right. It will draw smooth lines through our data.

Left-most column is defaulted to the horizontal axis. Right-most the vertical axis. Axis data is editable.

SAVE *ctrl+s*

You get the following:



- Charts can be edited with the "Chart Tools" tab that comes up. The "Chart Layouts" sub-tab will be important in labeling your graphs.
- Right-clicking on your graph data brings up options as well (you can rename your series, for example).

SAVE *ctrl+s*

Your turn:

- Create a graph of v_f versus t.
- Explore the "Chart Layout" sub-tab to label and title your graph.
- Charts are automatically updated if your data changes. Change your initial parameters.

Attachments

Complex Orbit.xlsx