Architectural Structures: Form, Behavior, and Design

Arch 331

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Fall 2013

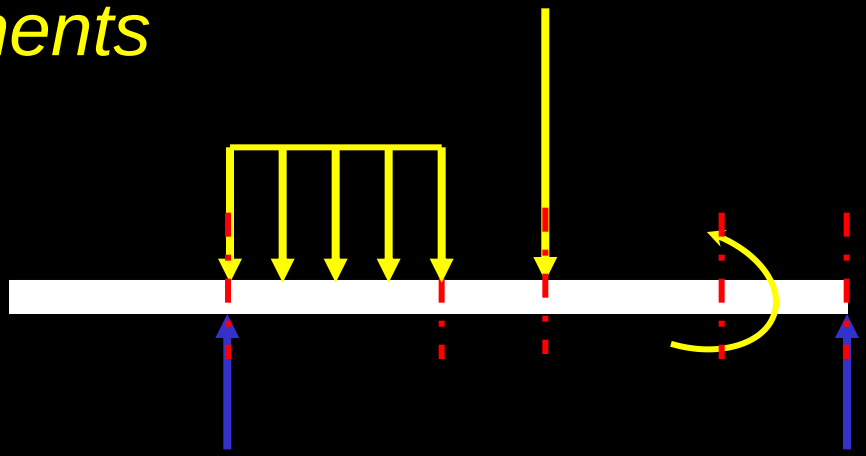
lecture eight

shear & bending moment diagrams

Forum, Pompeii

Equilibrium Method

- *important places*
  - *supports*
  - *concentrated loads*
  - *start and end of distributed loads*
  - *concentrated moments*
- *free ends*
  - *zero forces*



Semigraphical Method

- *by knowing*
  - *area under loading curve = change in V*
  - *area under shear curve = change in M*
  - *concentrated forces cause "jump" in V*
  - *concentrated moments cause "jump" in M*

$$V_D - V_C = -\int_{x_C}^{x_D} w\,dx \qquad M_D - M_C = \int_{x_C}^{x_D} V\,dx$$

Semigraphical M

- *relationships*

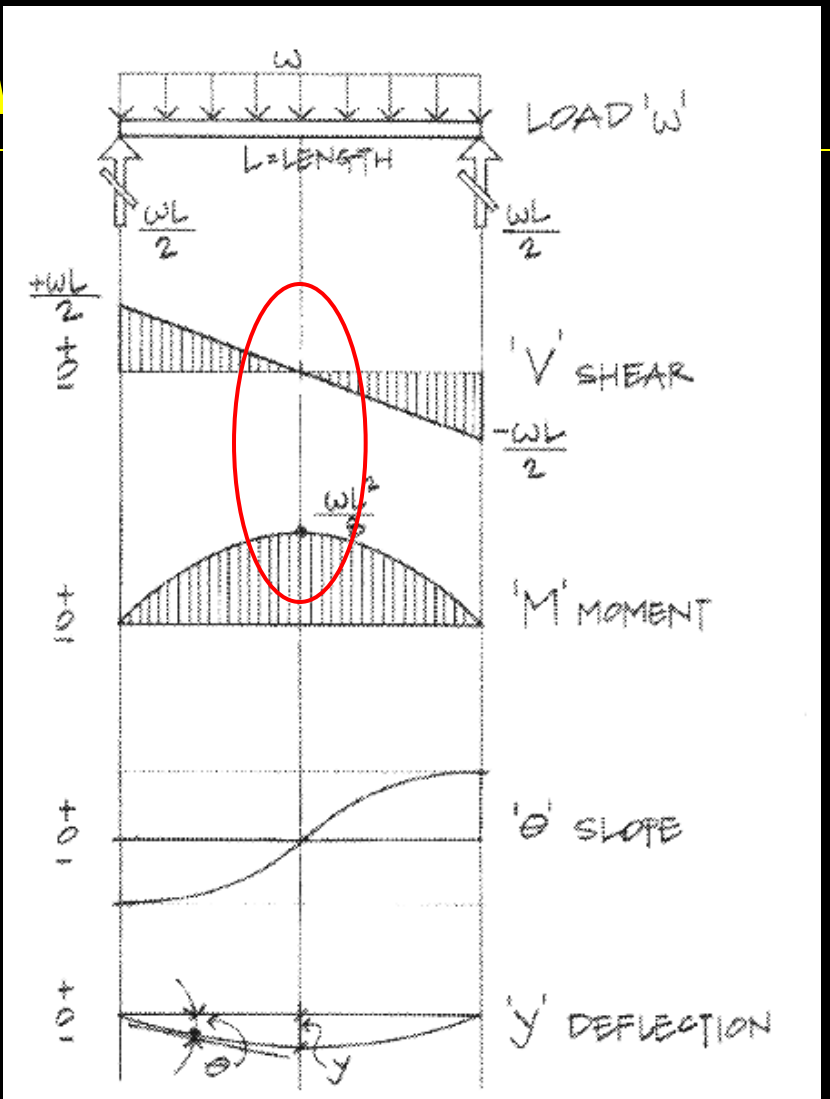
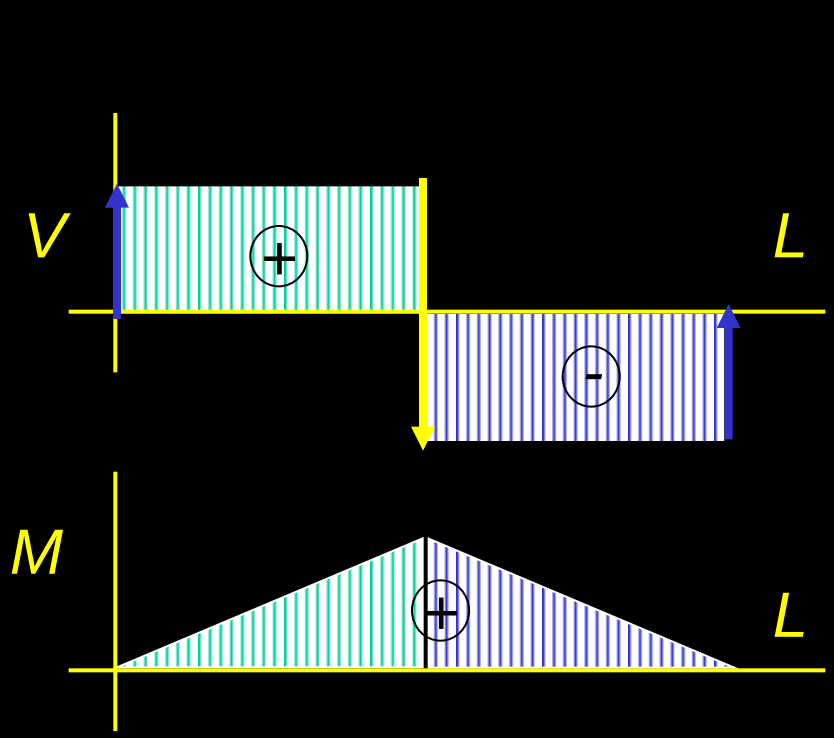
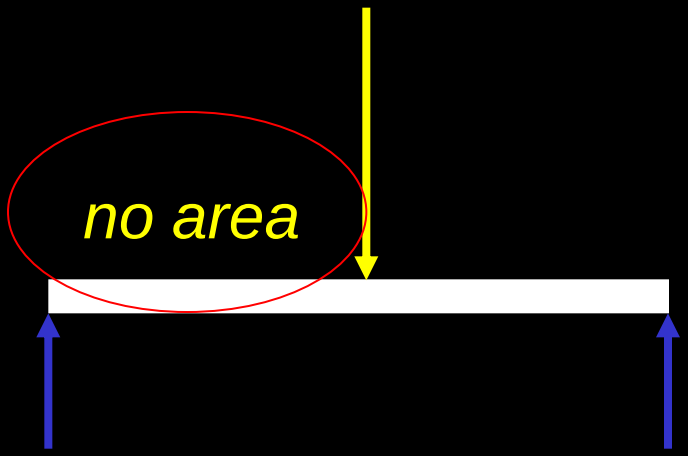


Figure 7.11 Relationship of load, shear, moment, slope, and deflection diagrams.

Semigraphical Method

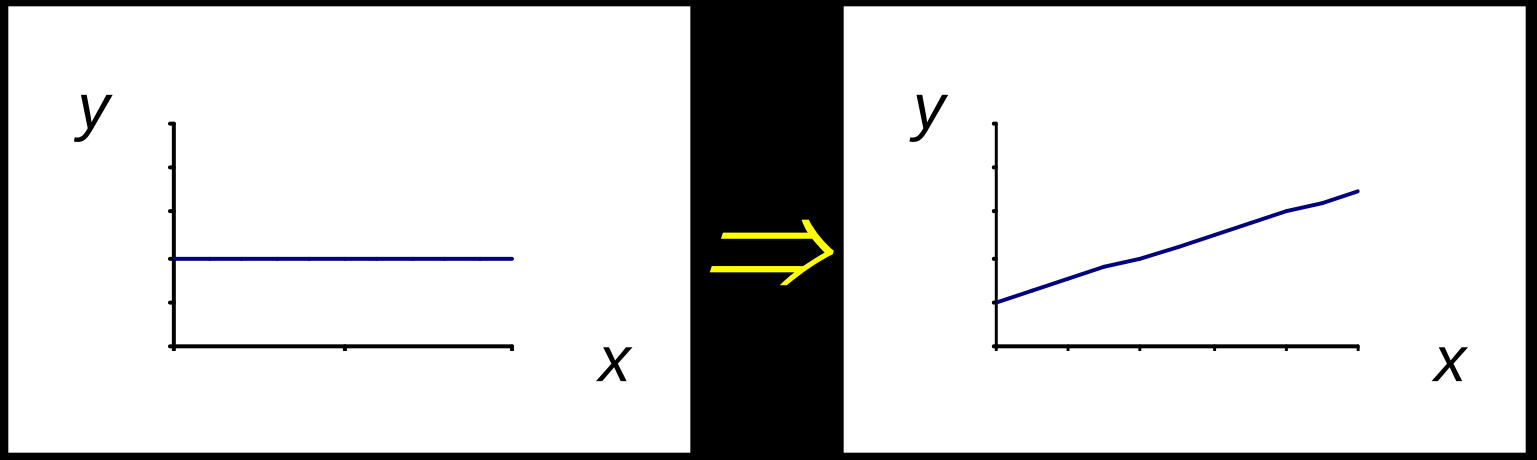
- M_{max} occurs where V = 0 (calculus)





Curve Relationships

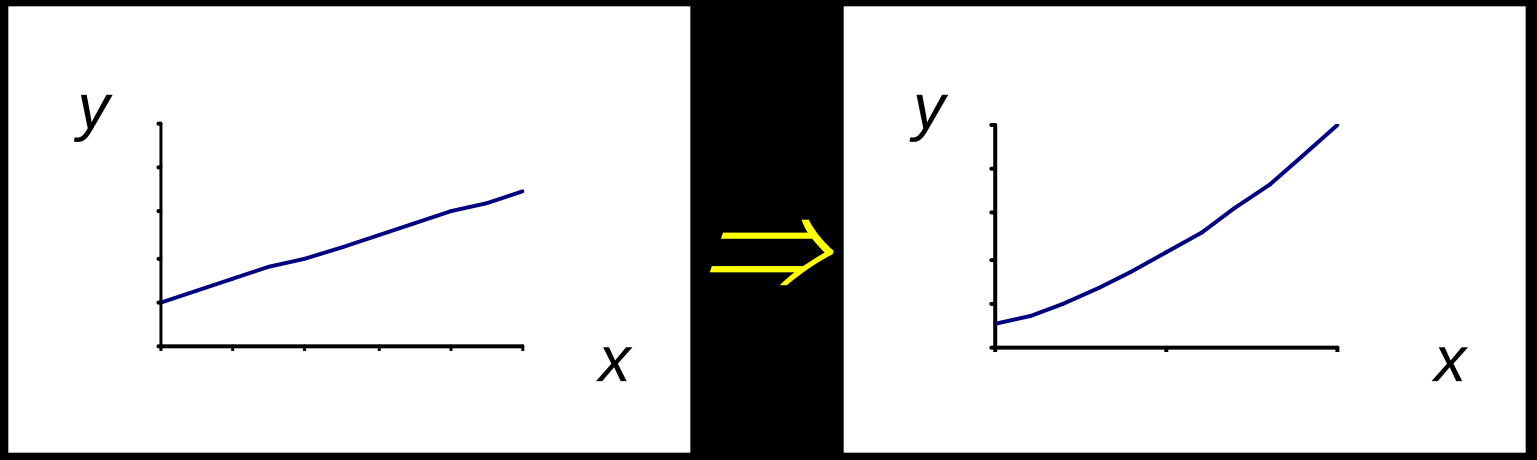
- *integration of functions*
- *line with 0 slope, integrates to sloped*



- *ex: load to shear, shear to moment*

Curve Relationships

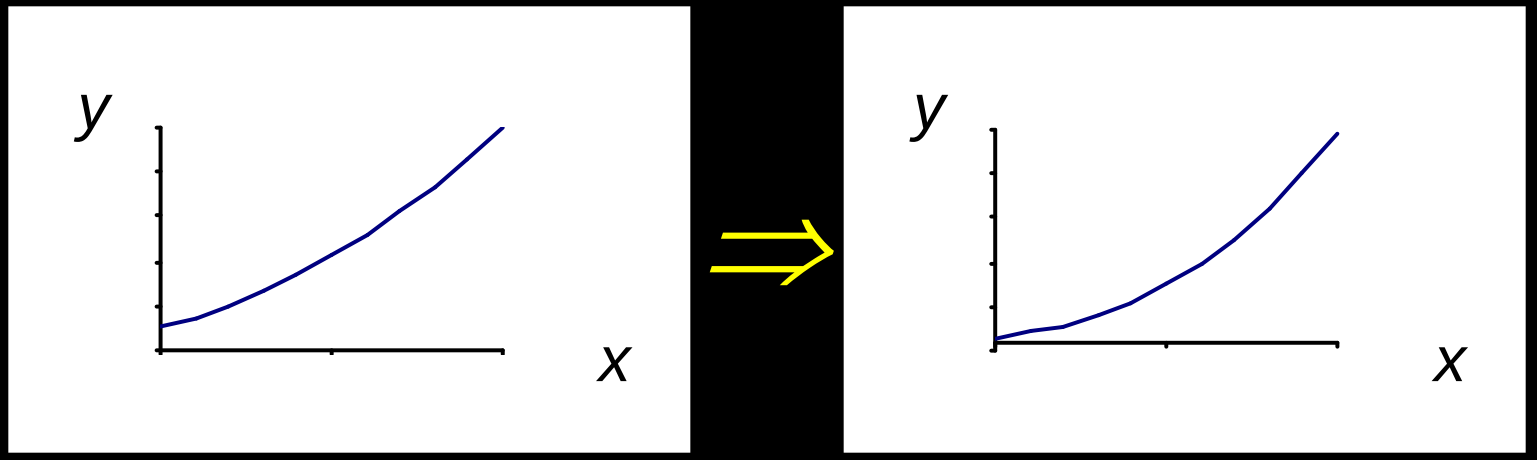
- *line with slope, integrates to parabola*



- *ex: load to shear, shear to moment*

Curve Relationships

- *parabola, integrates to 3rd order curve*



- *ex: load to shear, shear to moment*

Basic Procedure

1. *Find reaction forces & moments*

   Plot axes, underneath beam load diagram

V:

2. *Starting at left*
3. *Shear is 0 at free ends*
4. *Shear jumps with concentrated load*
5. *Shear changes with area under load*

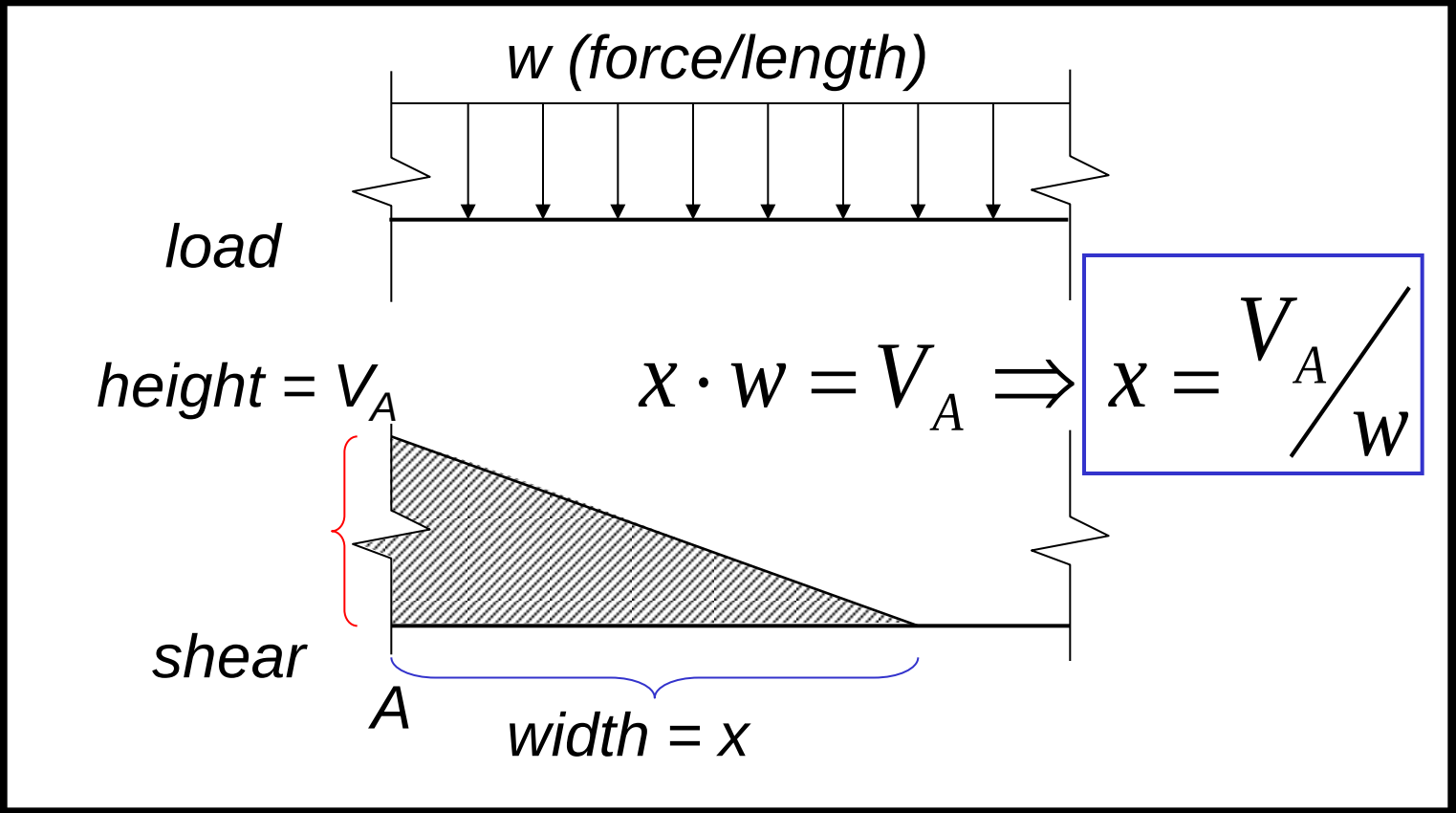
Basic Procedure

M:

6. *Starting at left*
7. *Moment is 0 at free ends*
8. *Moment jumps with moment*
9. *Moment changes with area under V*
10. *Maximum moment is where shear = 0! (locate where V = 0)*

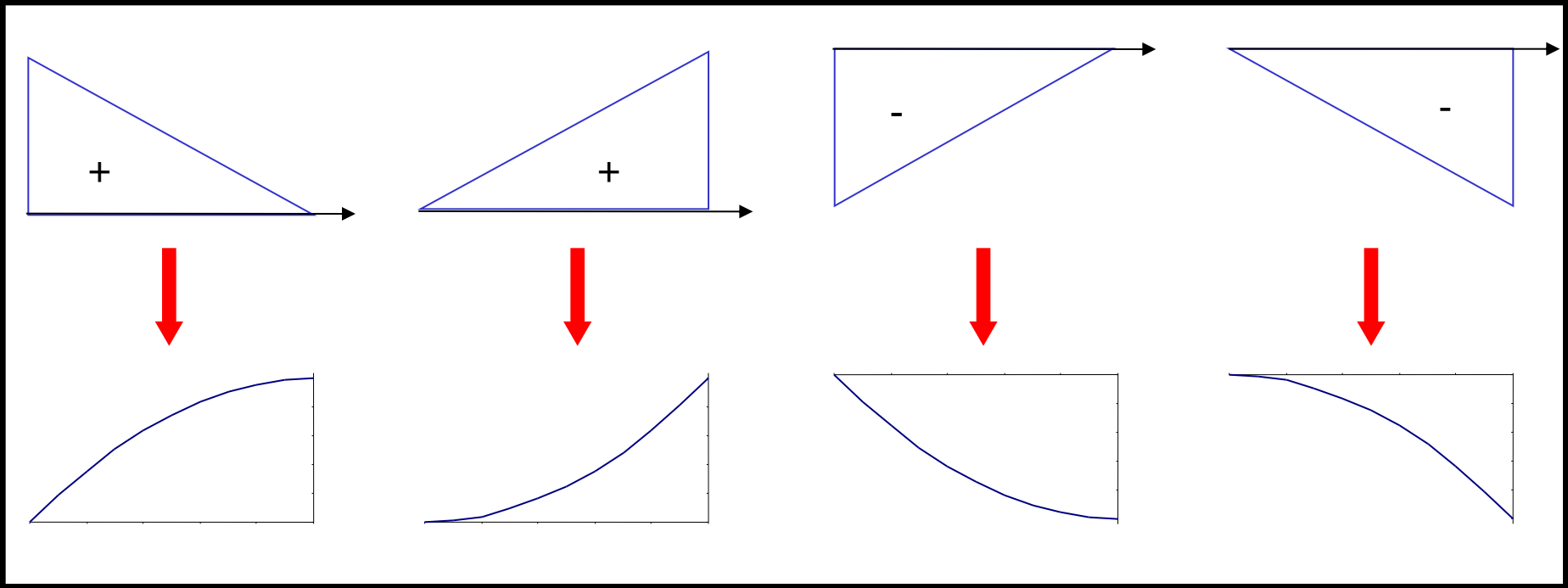
Shear Through Zero

- *slope of V is w (-w:1)*



Parabolic Shapes

- cases



up fast, then slow

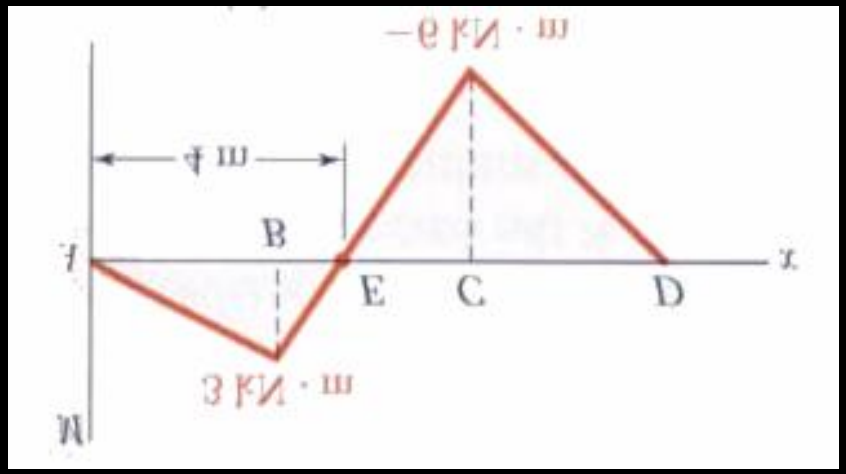
up slow, then fast

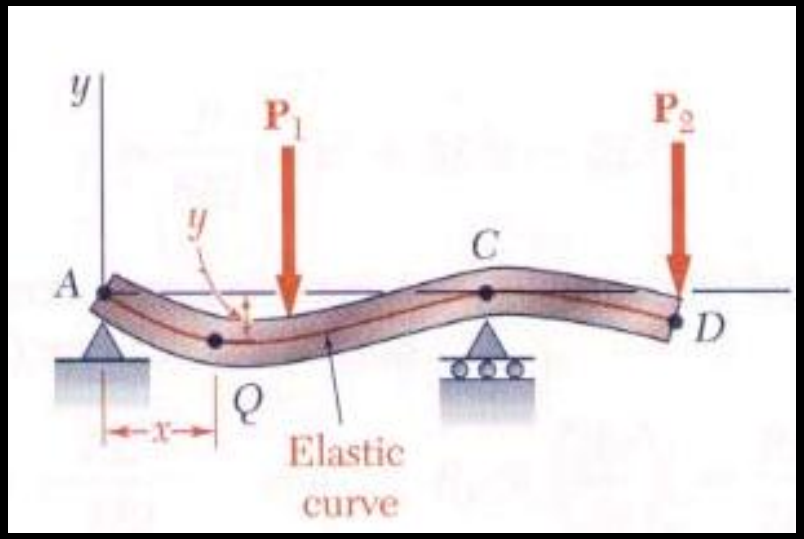
down fast, then slow

down slow, then fast

Deflected Shape & M(x)

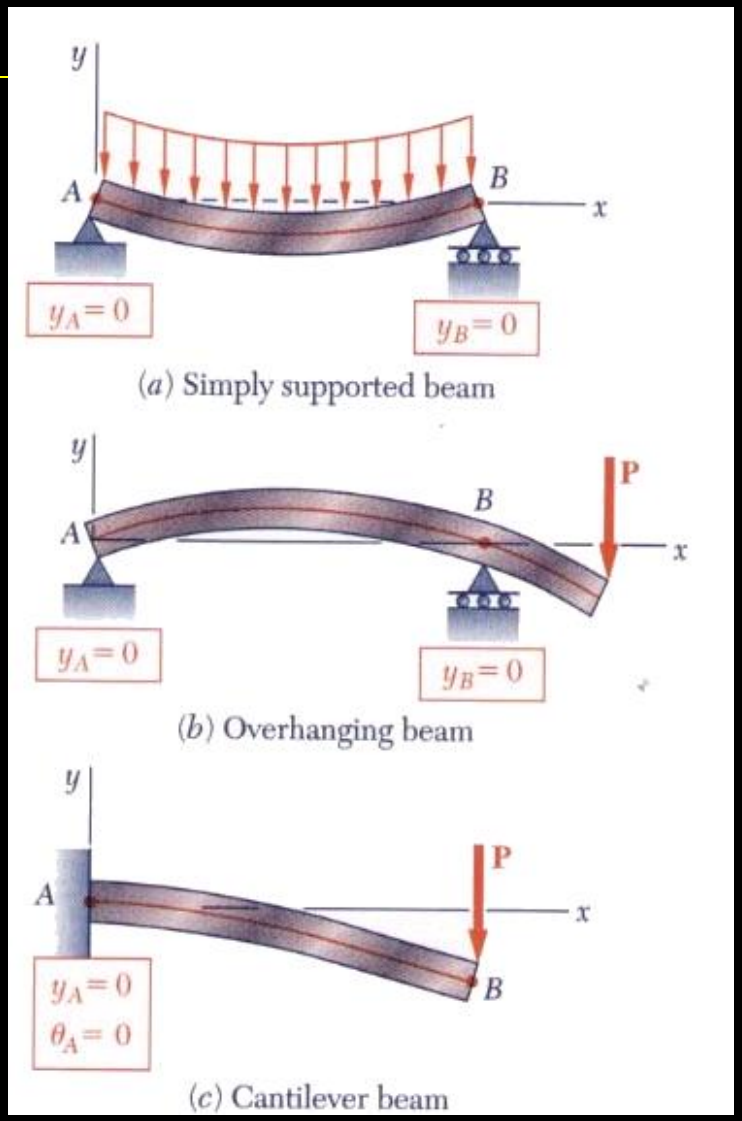
- *-M(x) gives shape indication*
- *boundary conditions must be met*





Boundary Conditions

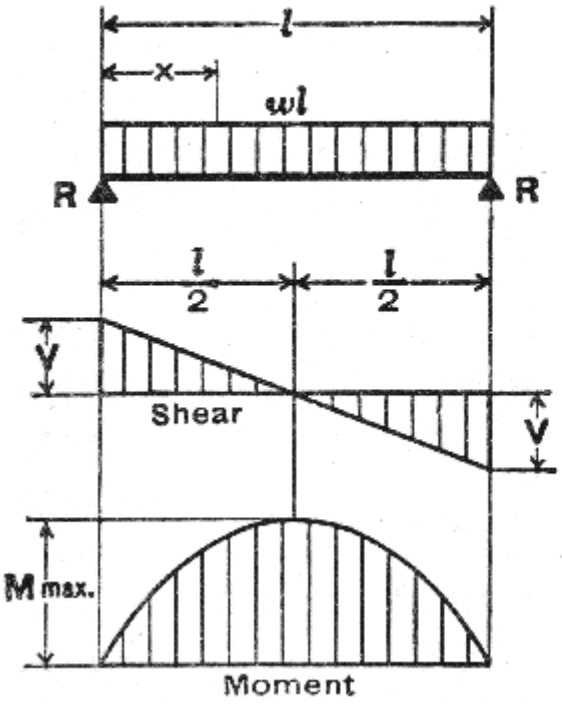
- *at pins, rollers, fixed supports:* $y = 0$
- *at fixed supports:* $\theta = 0$
- *at inflection points from symmetry:* $\theta = 0$
- y_{max} *at* $\dfrac{dy}{dx} = 0$



Tabulated Beam Formulas

- *how to read charts*

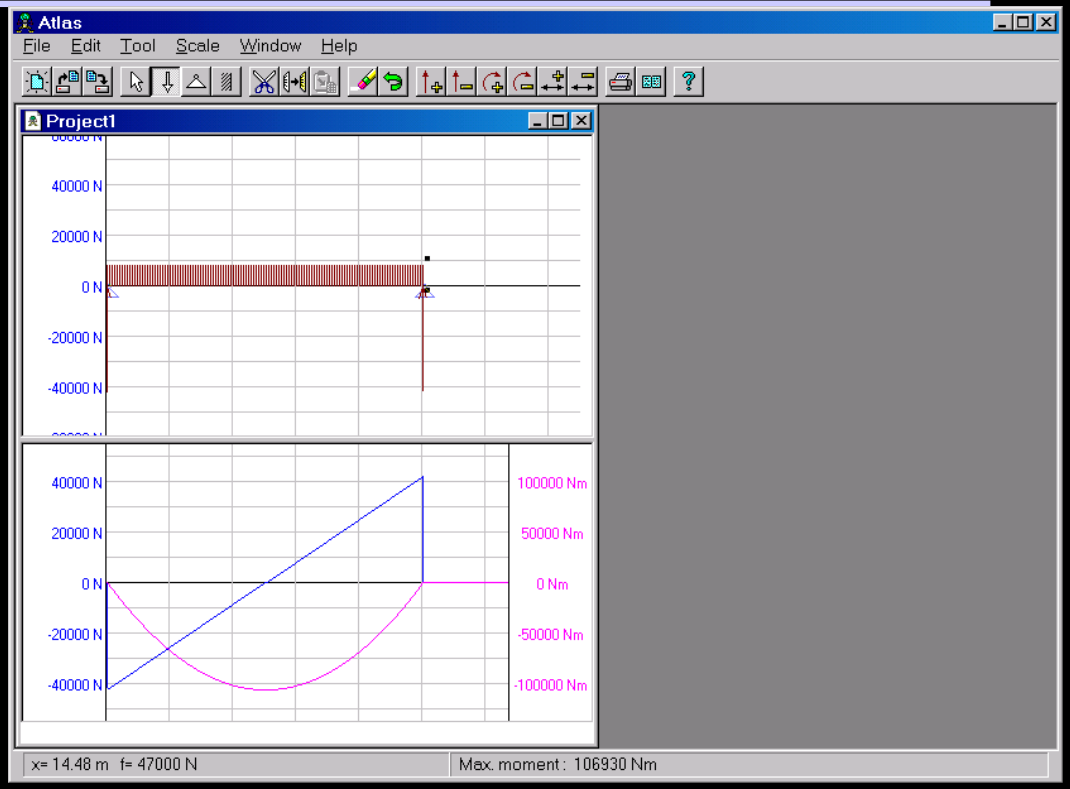
1. SIMPLE BEAM—UNIFORMLY DISTRIBUTED LOAD



Total Equiv. Uniform Load . . .	$= wl$
$R = V$	$= \frac{wl}{2}$
V_x	$= w\left(\frac{l}{2} - x\right)$
M max. (at center)	$= \frac{wl^2}{8}$
M_x	$= \frac{wx}{2}(l - x)$
Δmax. (at center)	$= \frac{5\,wl^4}{384\,EI}$
Δ_x	$= \frac{wx}{24EI}(l^3 - 2lx^2 + x^3)$

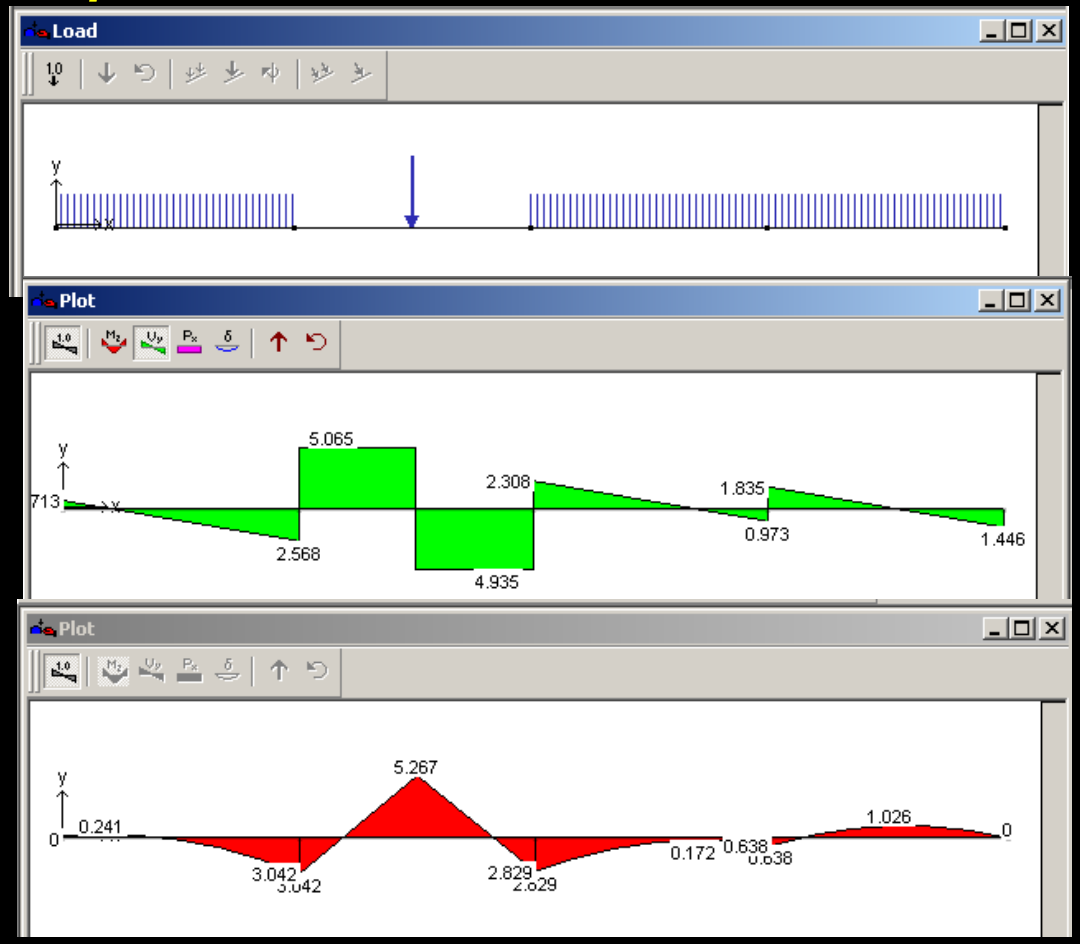
Tools

- *software & spreadsheets help*
- *http://www.rekenwonder.com/atlas.htm*



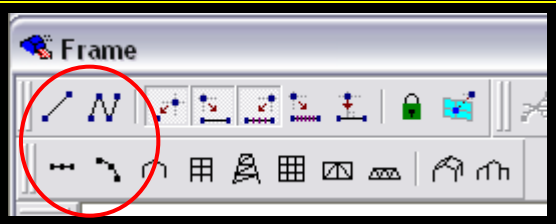
Tools – Multiframe

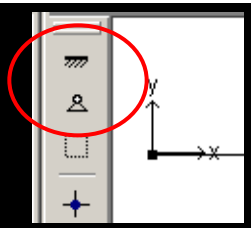
- *in computer lab*

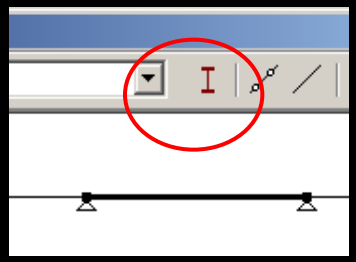


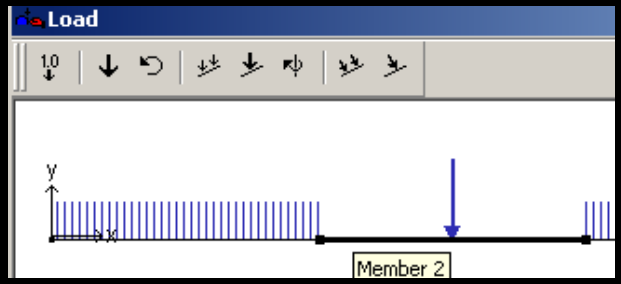
Tools – Multiframe

- *frame window*
  - *define beam members*
  - *select points, assign supports*
  - *select members, assign section*
- *load window*
  - *select point or member, add point or distributed loads*



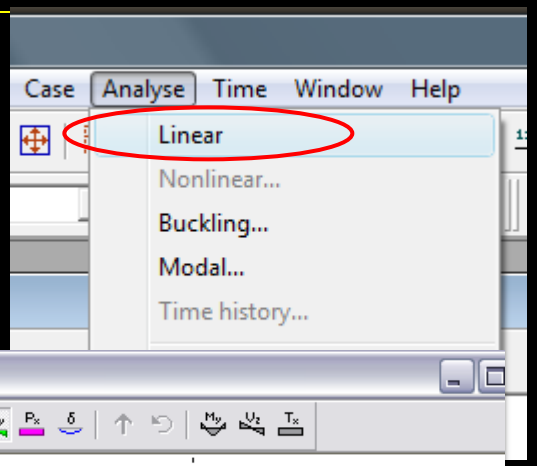


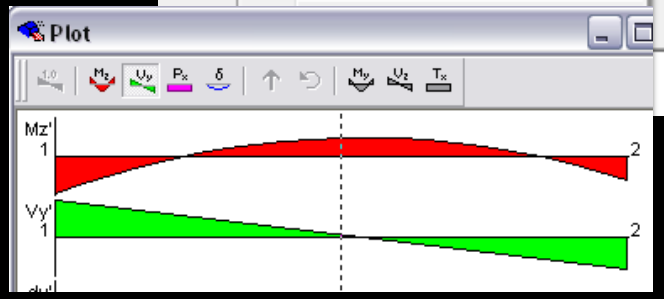




Tools – Multiframe

- to run analysis choose
  - Analyze menu
    - Linear
- plot
  - choose options
  - double click (all)
- results
  - choose options





Result

Static Case: Load Case 1

	Joint	Label	Rx' kip	Ry' kip	Mz' kip-ft
1	1		0.000	-0.000	0.000
2	2		0.000	9.250	0.000
3	3		0.000	6.102	0.000
4	4		0.000	3.093	0.000
5	5		0.000	1.398	-0.000
6	**Total**	**(Global)**	**Rx=0.000**	**Ry=19.843**	

Displacements | Reactions