How Beams Work, I

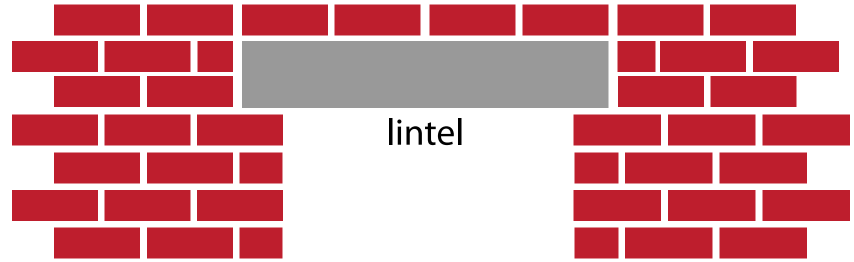
Statics and Strength of Materials

HOW BEAMS WORK

Beams work by transferring transverse loads along their length to their supports primarily by resisting a force called *internal bending moment*.

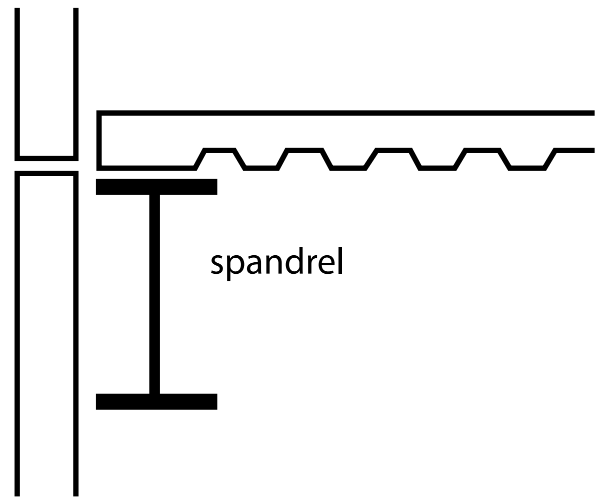
BEAM TYPES : FUNCTIONAL DISTINCTION

joists
closely spaced beams supporting floors and roofs



lintels
beams over masonry wall openings

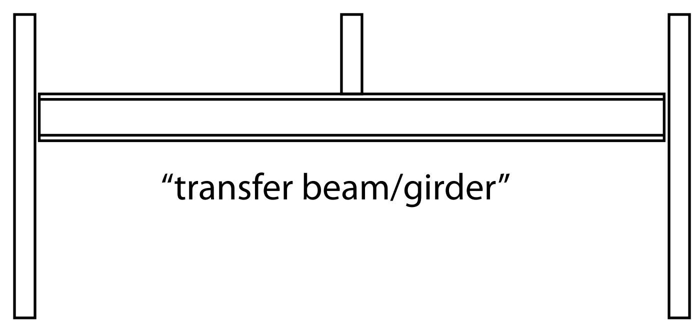
spandrel beams
supporting exterior walls and sometimes the floors



stringers
bridge beams parallel to the roadway

floor beams
large beams perpendicular to the roadway that transfer
loads from the stringers to the supporting trusses or girders

girder
large beam into which other beams are framed



BENDING OVERVIEW

What are the forces the member must resist? Primarily “bending,” which is a combination of:

1) A “force couple” of tension and compression
2) Shear (vertical and horizontal)
3) Torsion
4) Bearing

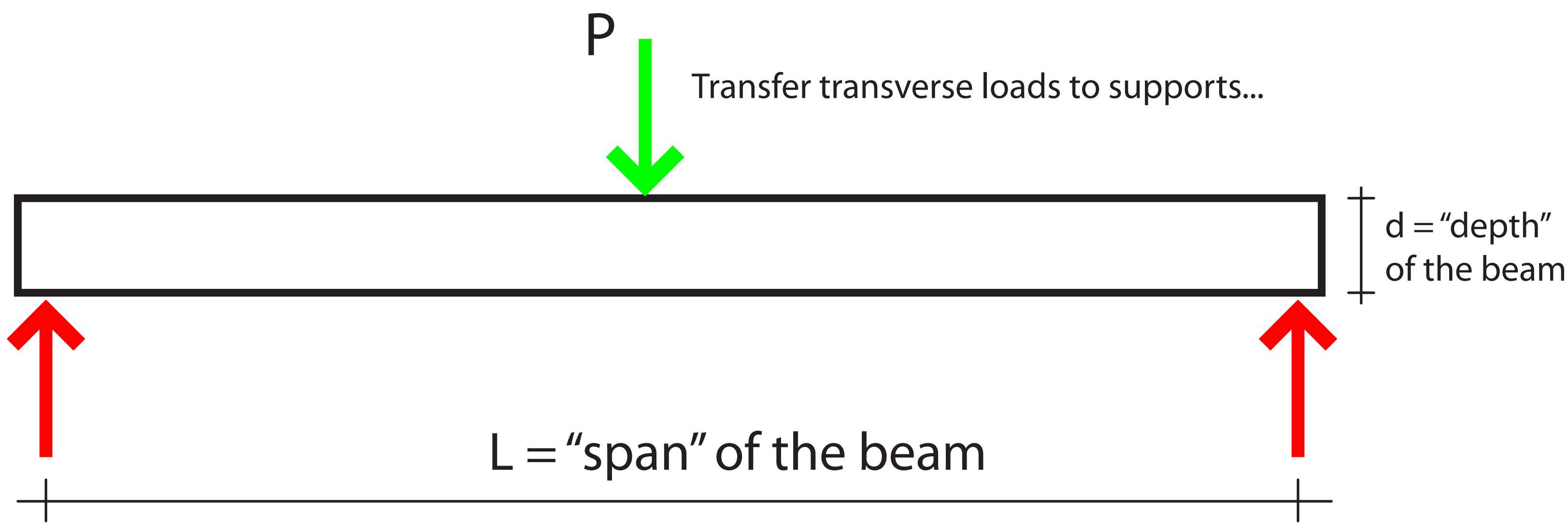
Factors that influence beam strength

GEOMETRY
1) length (”span”) of beam
2) depth of beam
3) shape of cross section

MATERIAL
1) modulus of elasticity
2) failure/yield stress

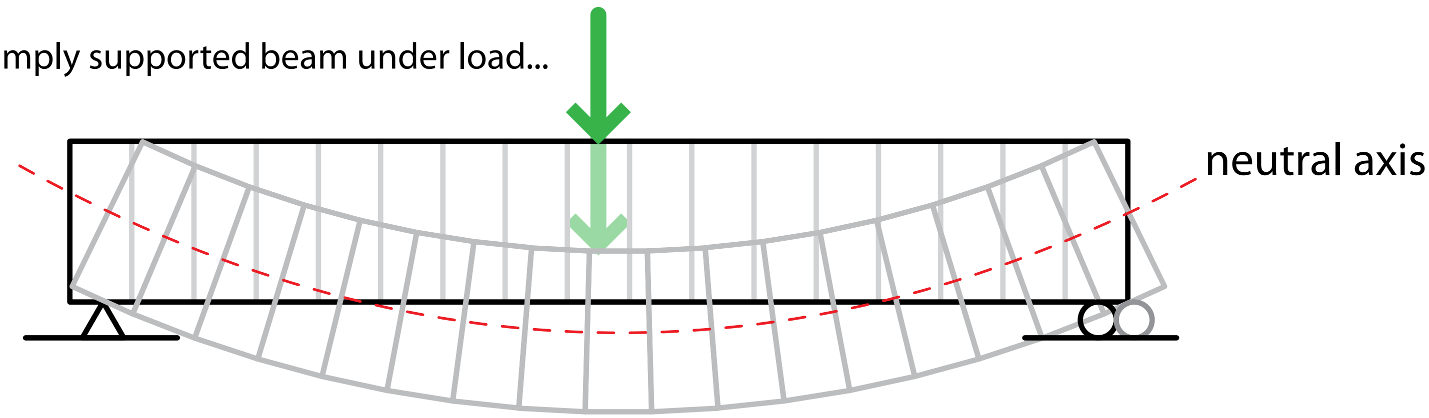
DESIGN FACTORS
1) Internal Bending Moment
2) Horizontal Shear
3) Vertical Shear
4) Bearing
5) Torsion
6) Loading conditions
7) Support and bracing conditions

BEAM THEORY


P
Transfer transverse loads to supports...
d = "depth"
of the beam
L = "span" of the beam

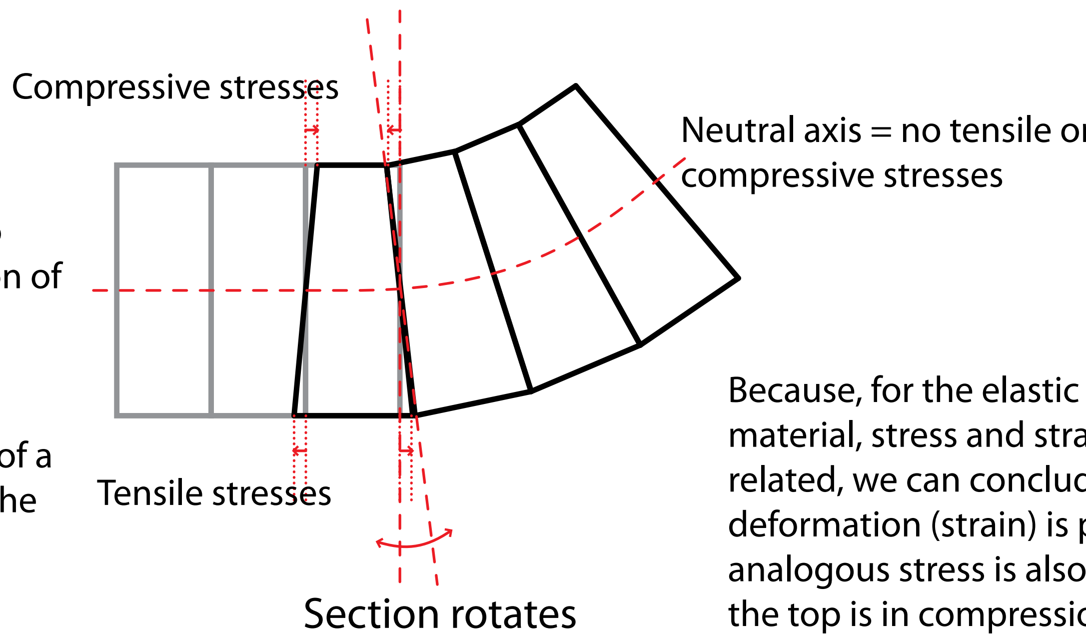
BEAM THEORY

Take a simply supported beam under load...



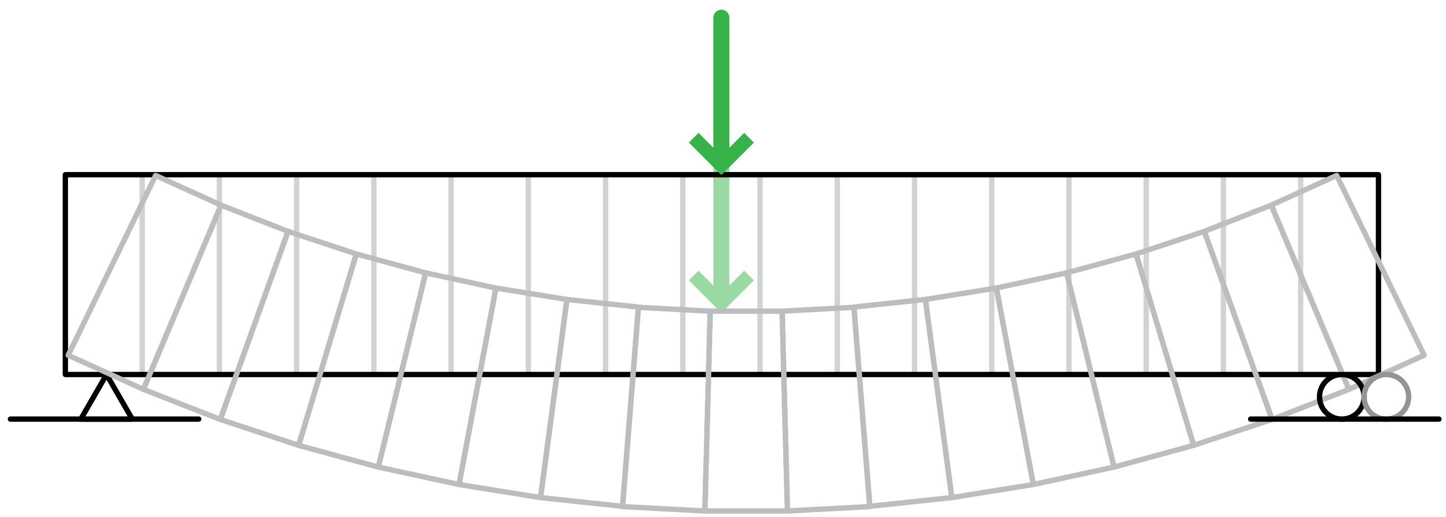
One model of describing beam action is to divide the beam into segments and discuss the motion of a single segment as the beam deforms.

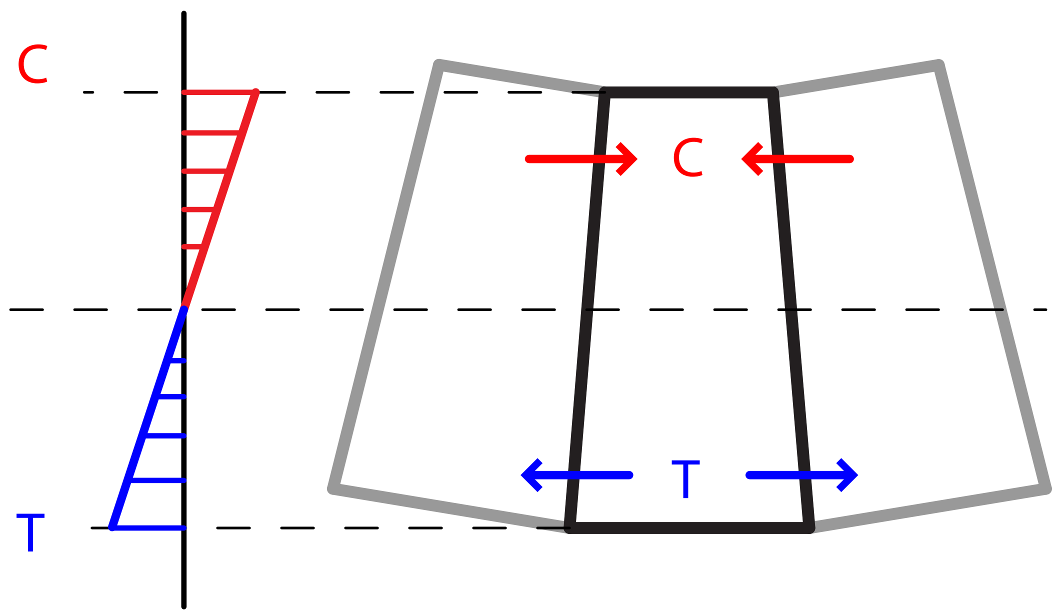
As we observe the deformation of a single segment, we notice that the top side of each segment is squeezed and the bottom side spreads.



Because, for the elastic range of the material, stress and strain are directly related, we can conclude that where deformation (strain) is present, the analogous stress is also present. Thus, the top is in compression, and the bottom in tension.

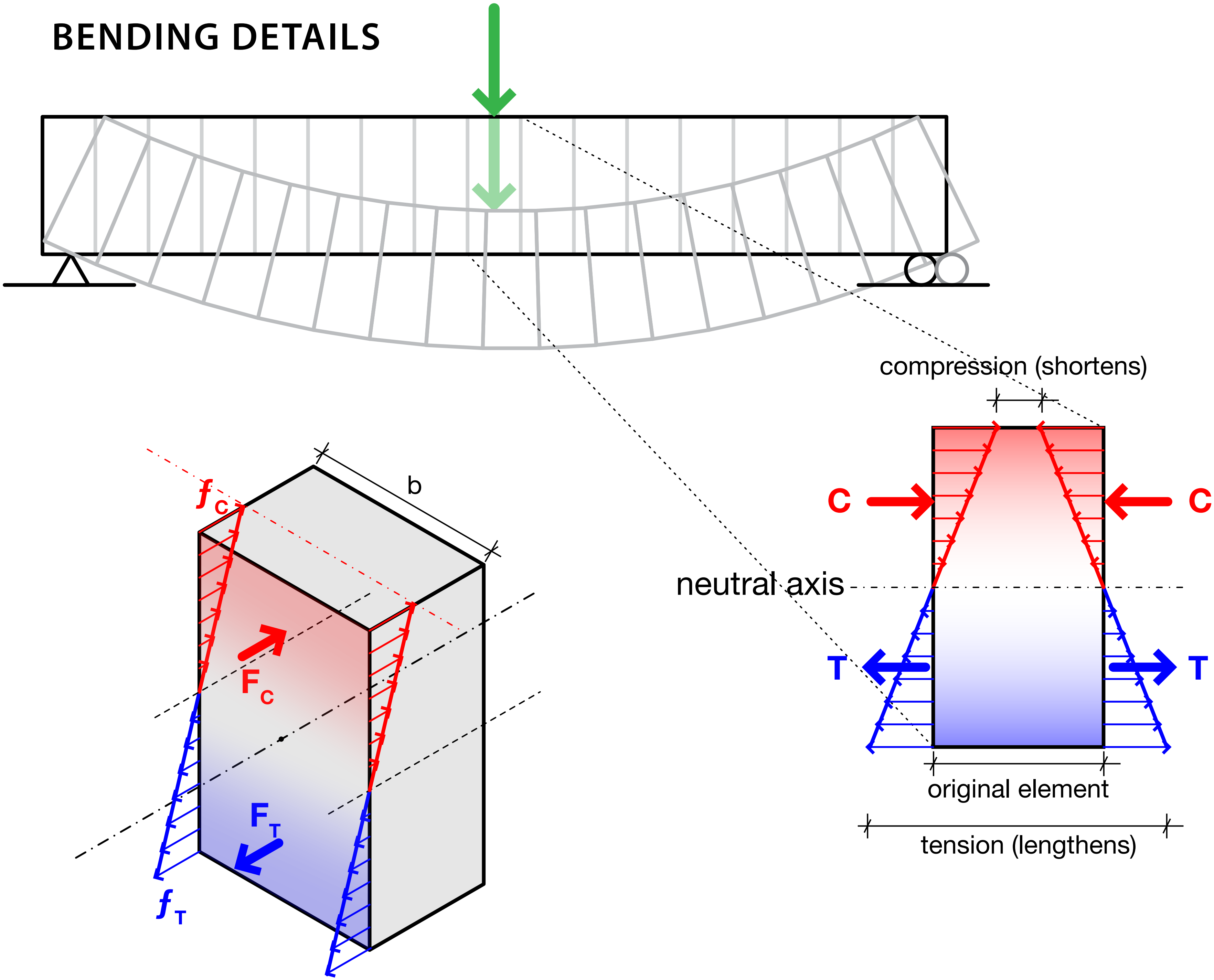
BEAM THEORY



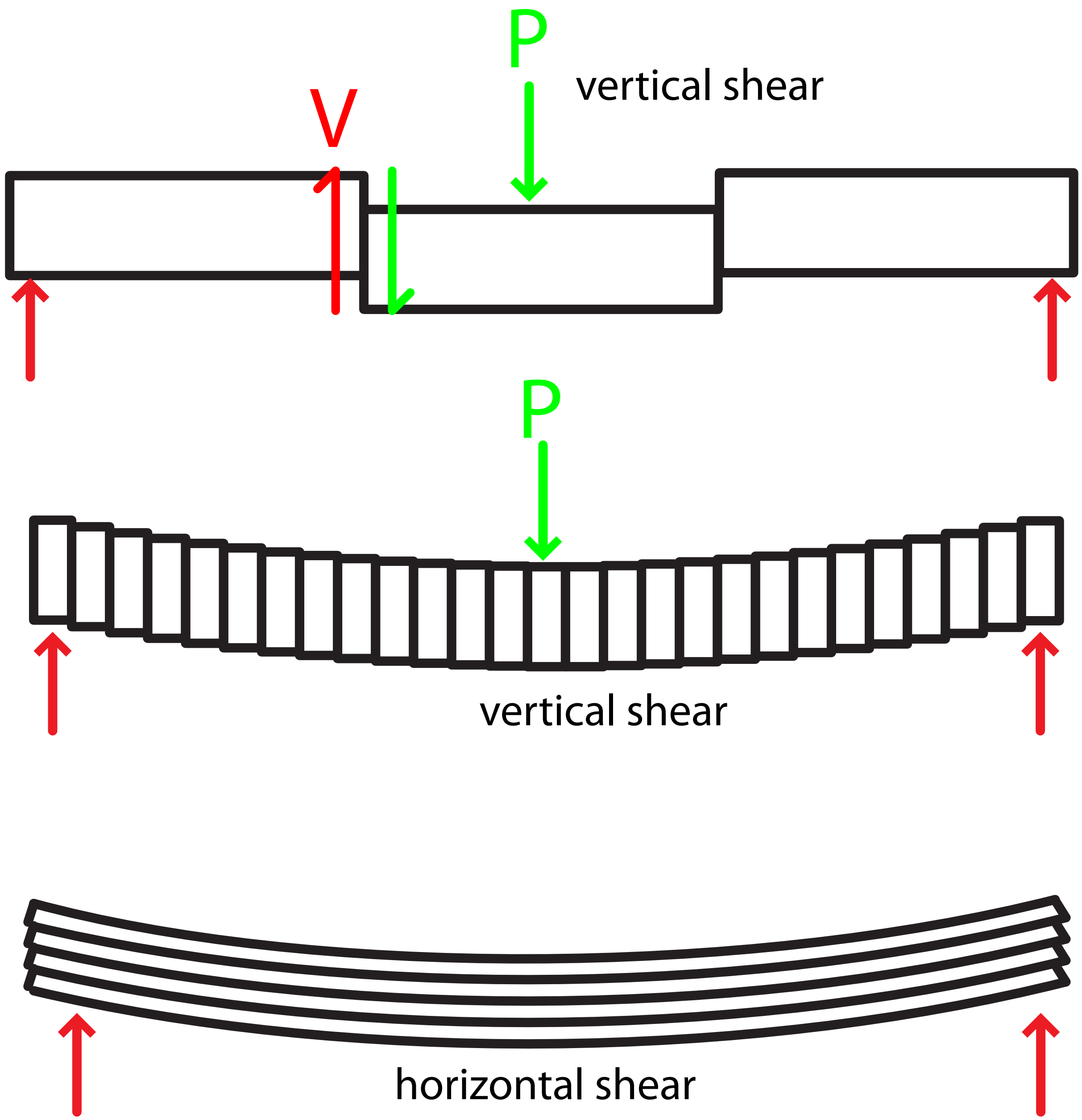


As a beam bends, the force couple formed by compression in the top fibers and tension in the bottom fibers creates what is called "internal bending moment." The ability of a beam to resist this force is the primary determining factor for the strength of the beam.

BENDING DETAILS



INTERNAL SHEAR

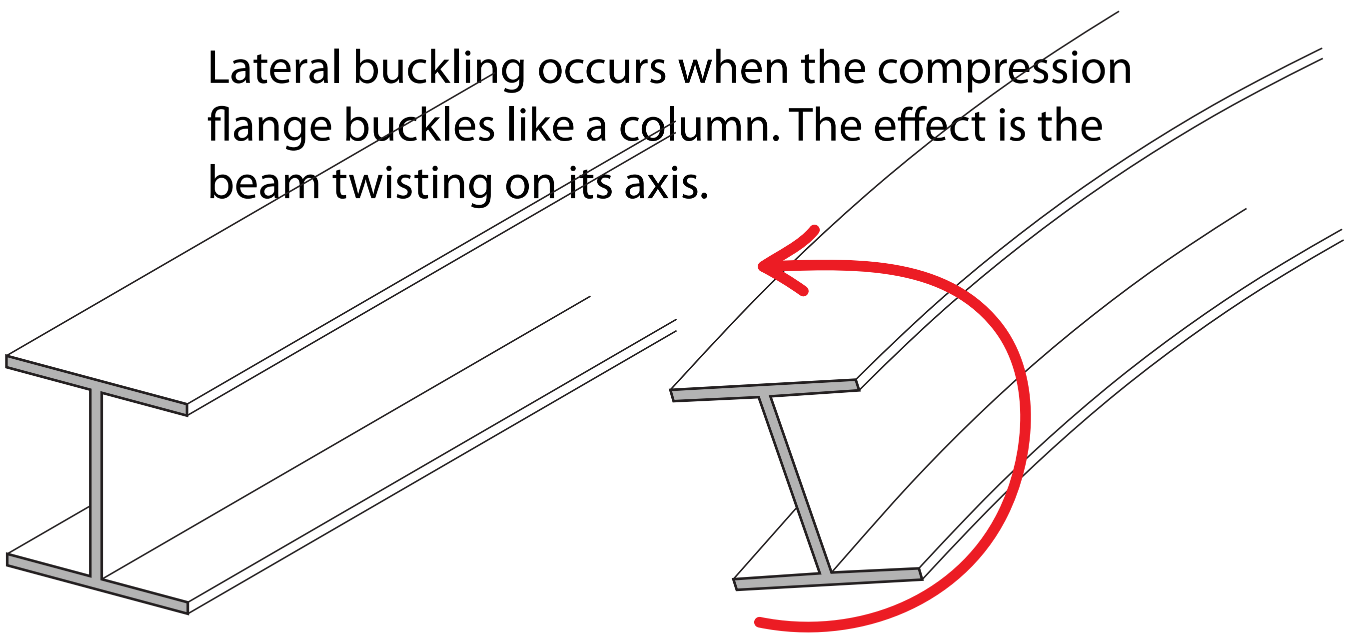


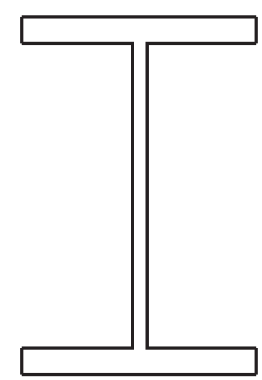
MODES OF FAILURE

What are the modes of failure for each one of those forces?

1) Bending failure (local buckling, tension failure)
2) Shear (horizontal shear failure)
3) Torsion (lateral buckling)
4) Bearing failure (at support or point loads)

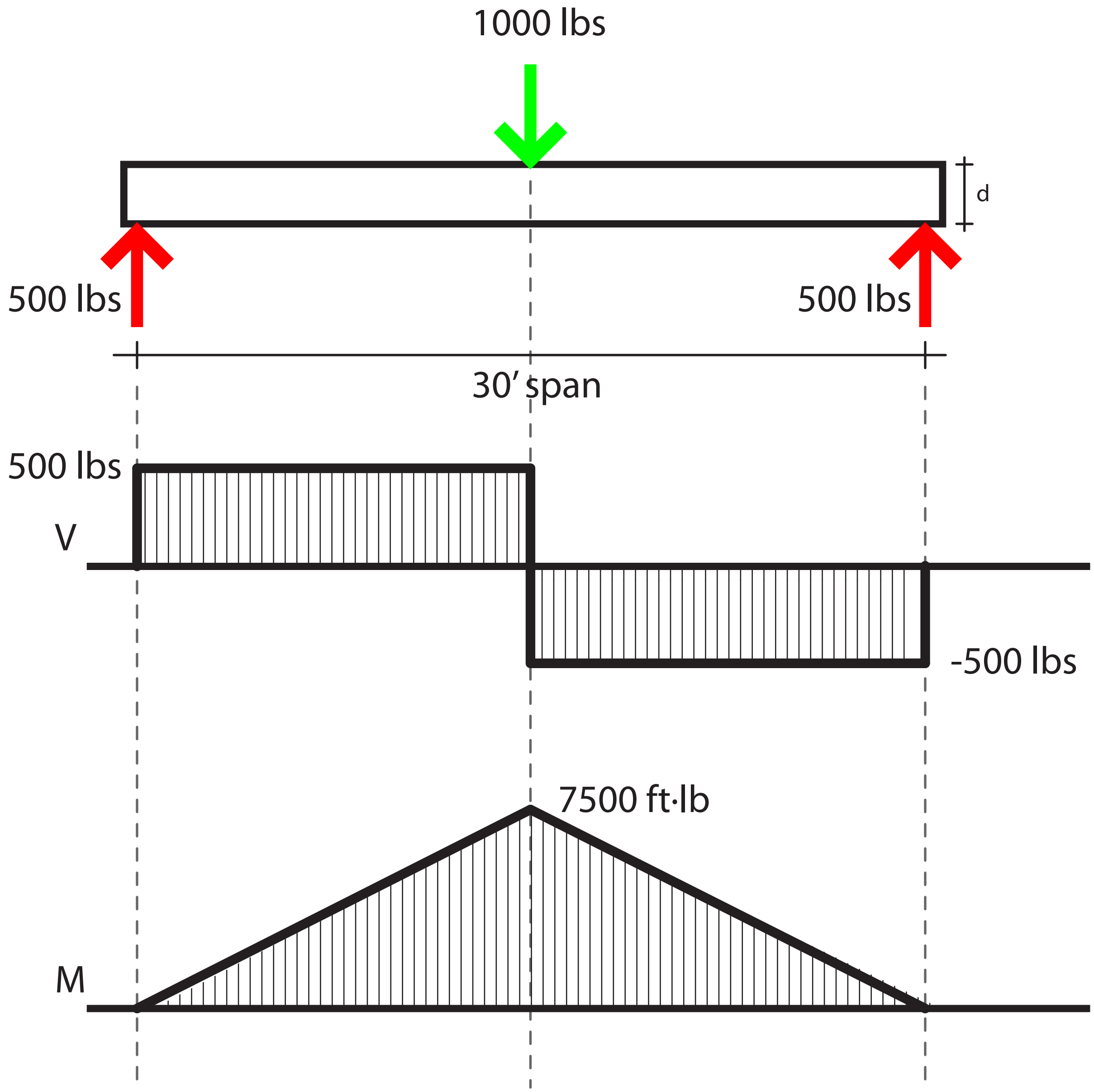
Lateral buckling occurs when the compression flange buckles like a column. The effect is the beam twisting on its axis.



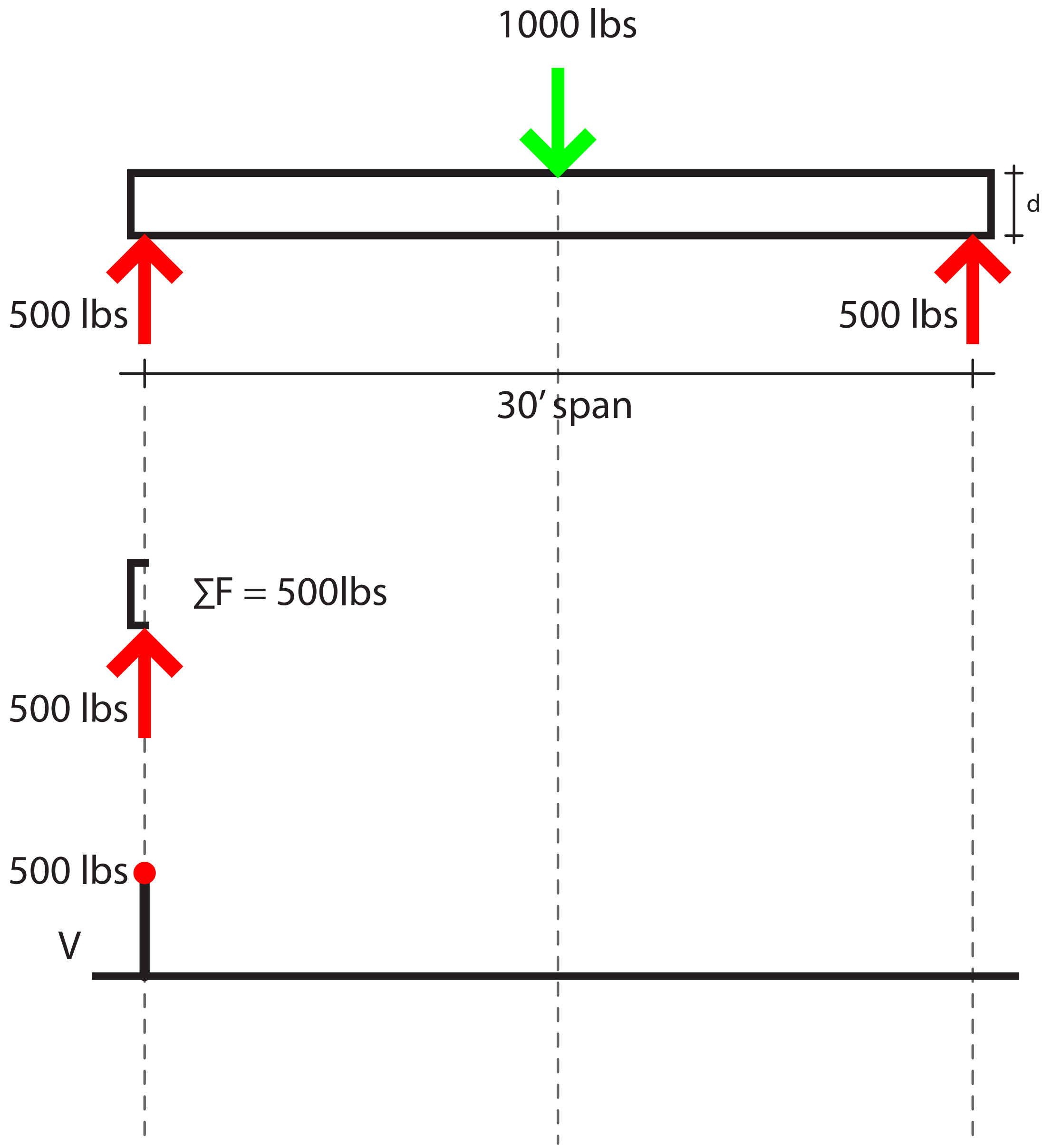


SHEAR AND MOMENT DIAGRAMS

Graphic representations of the magnitudes of internal forces (vertical shear and internal bending moment) along the length of a beam.



DRAWING THE SHEAR DIAGRAM



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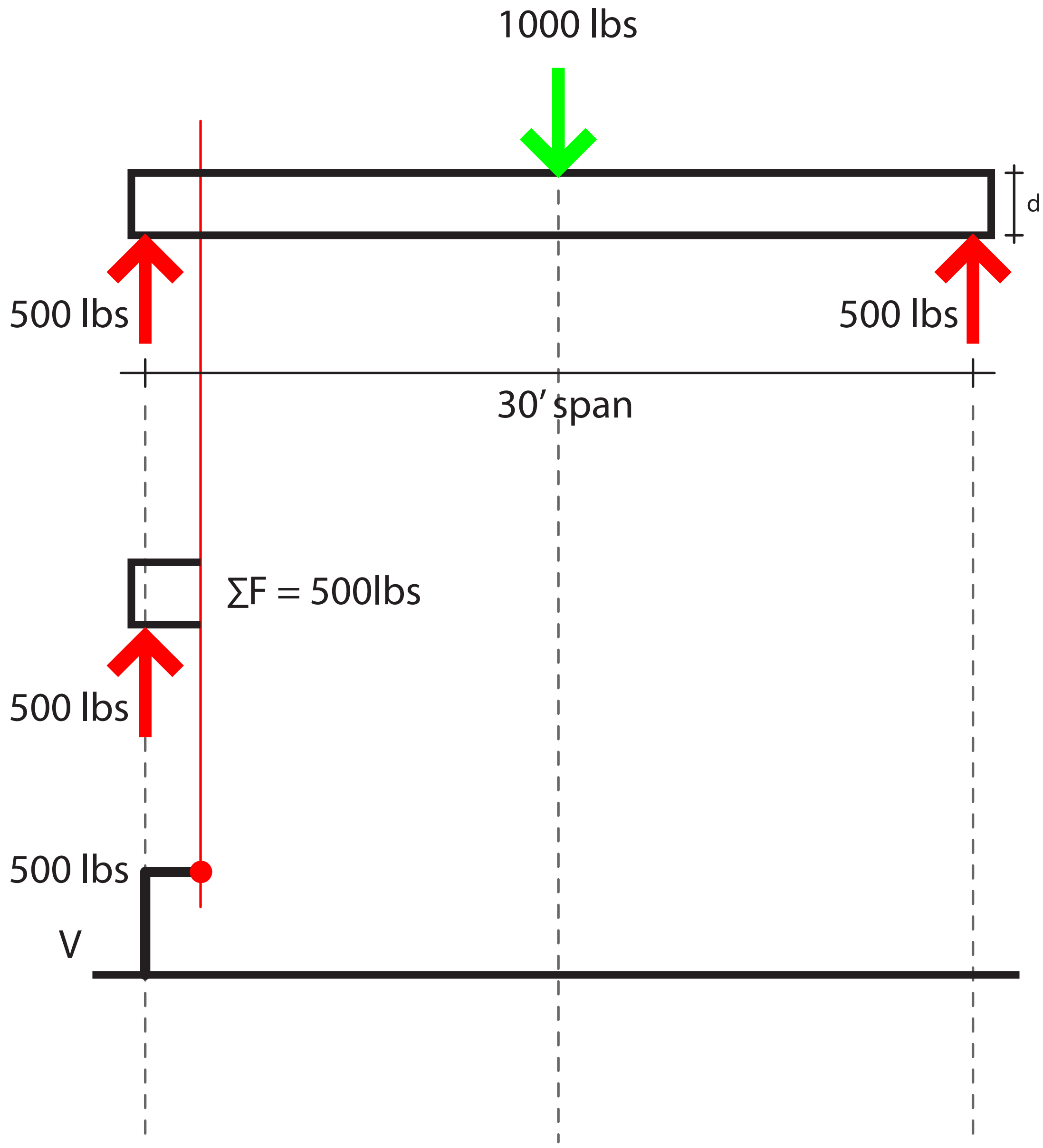

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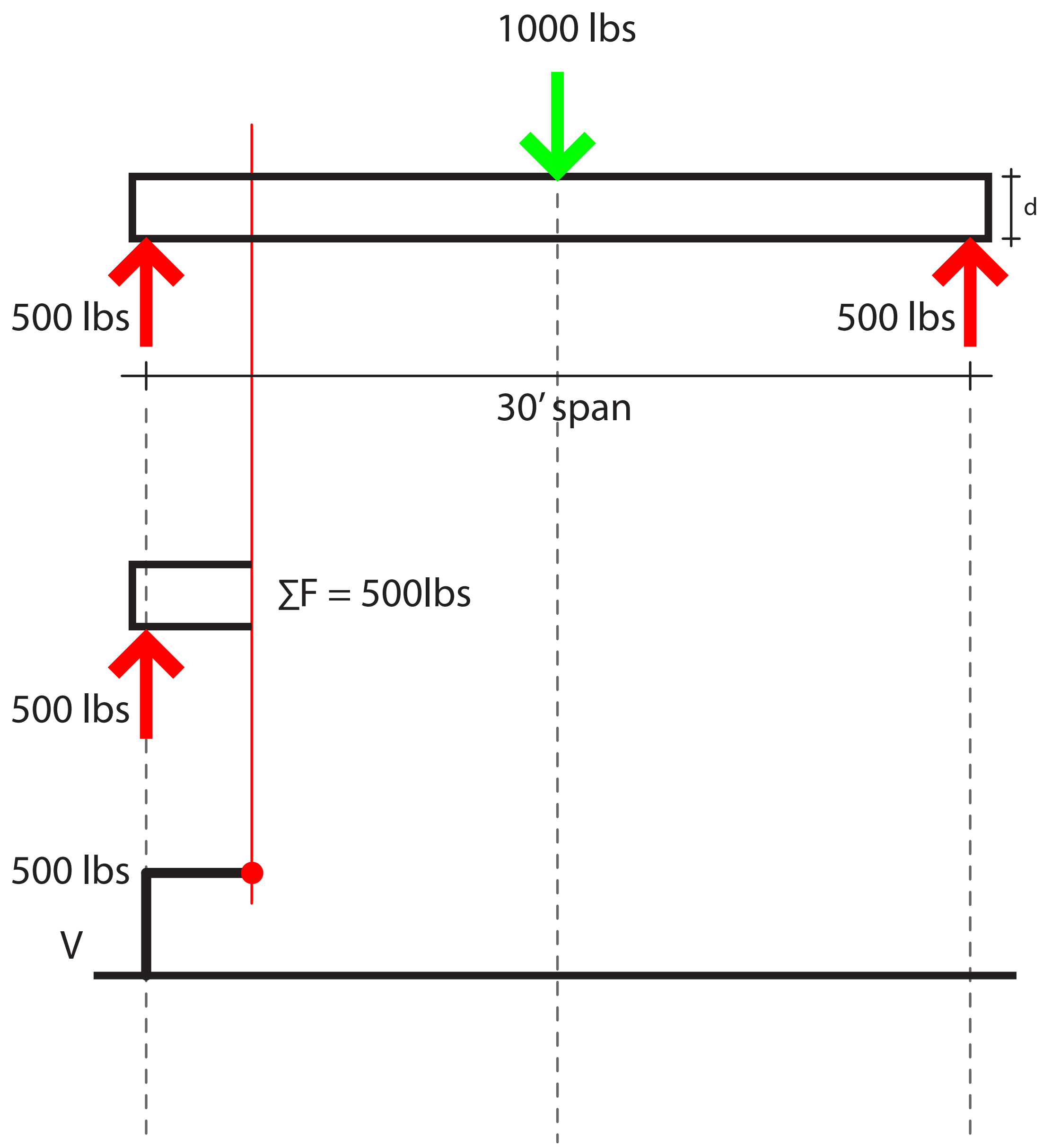

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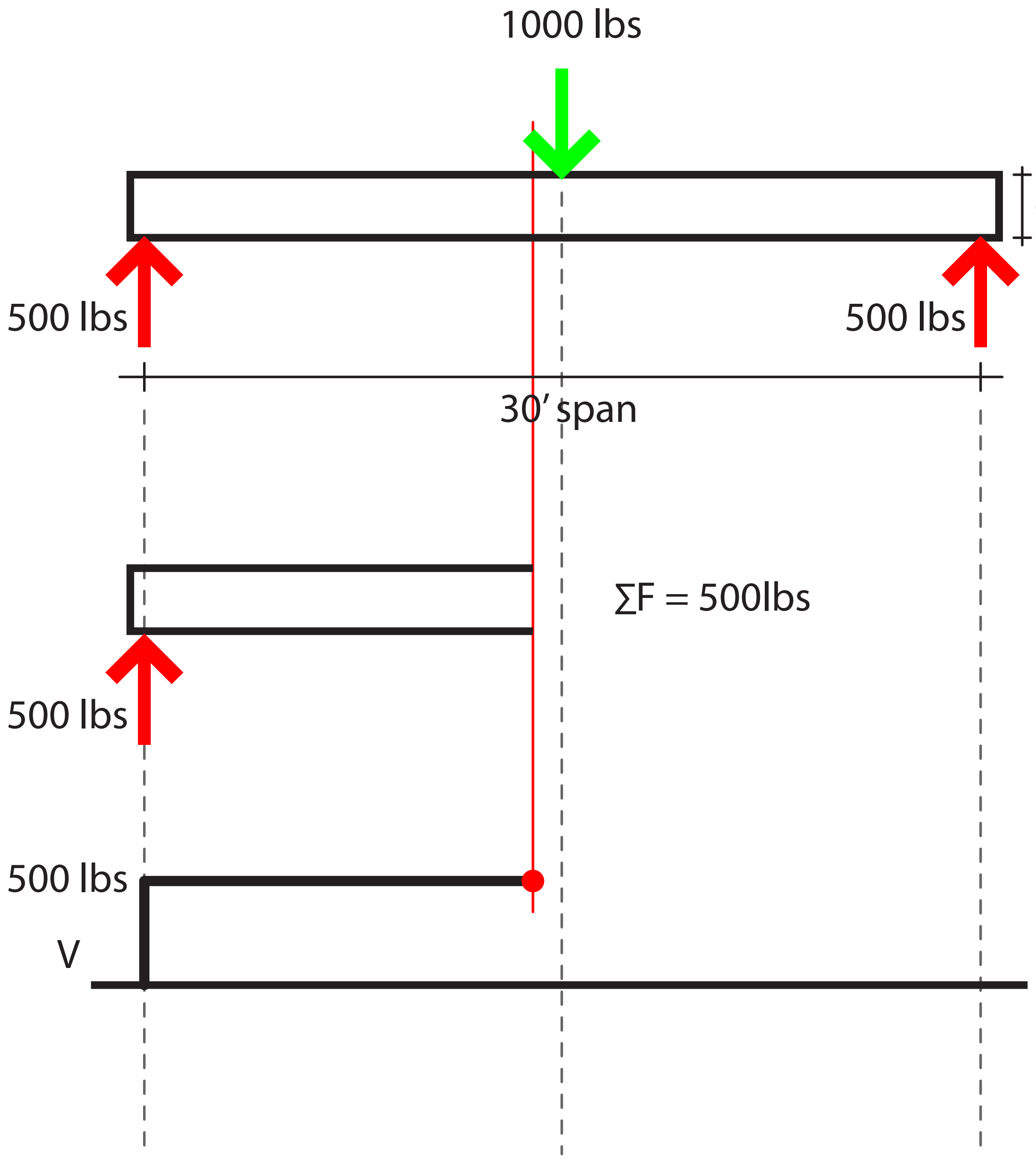

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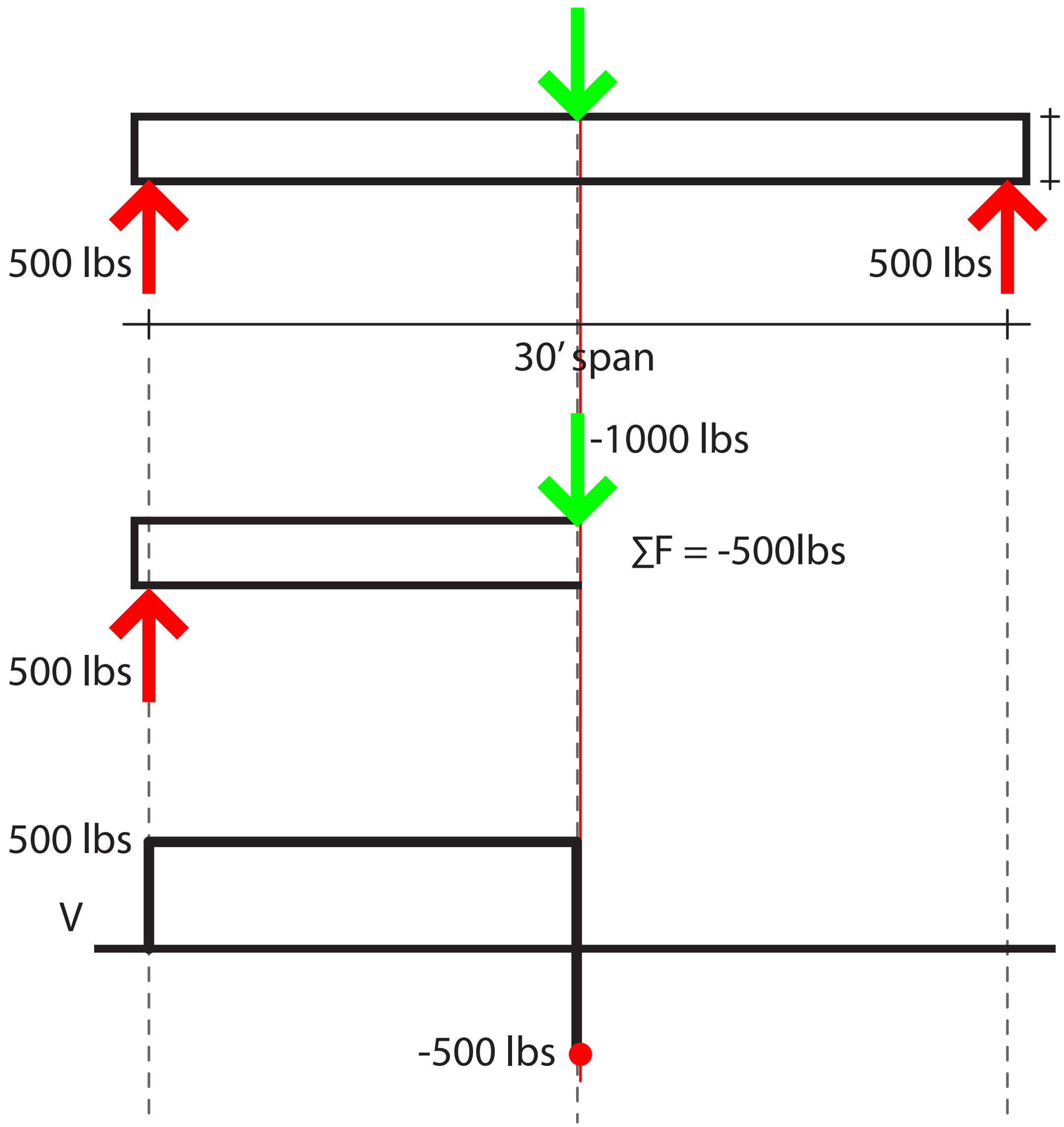

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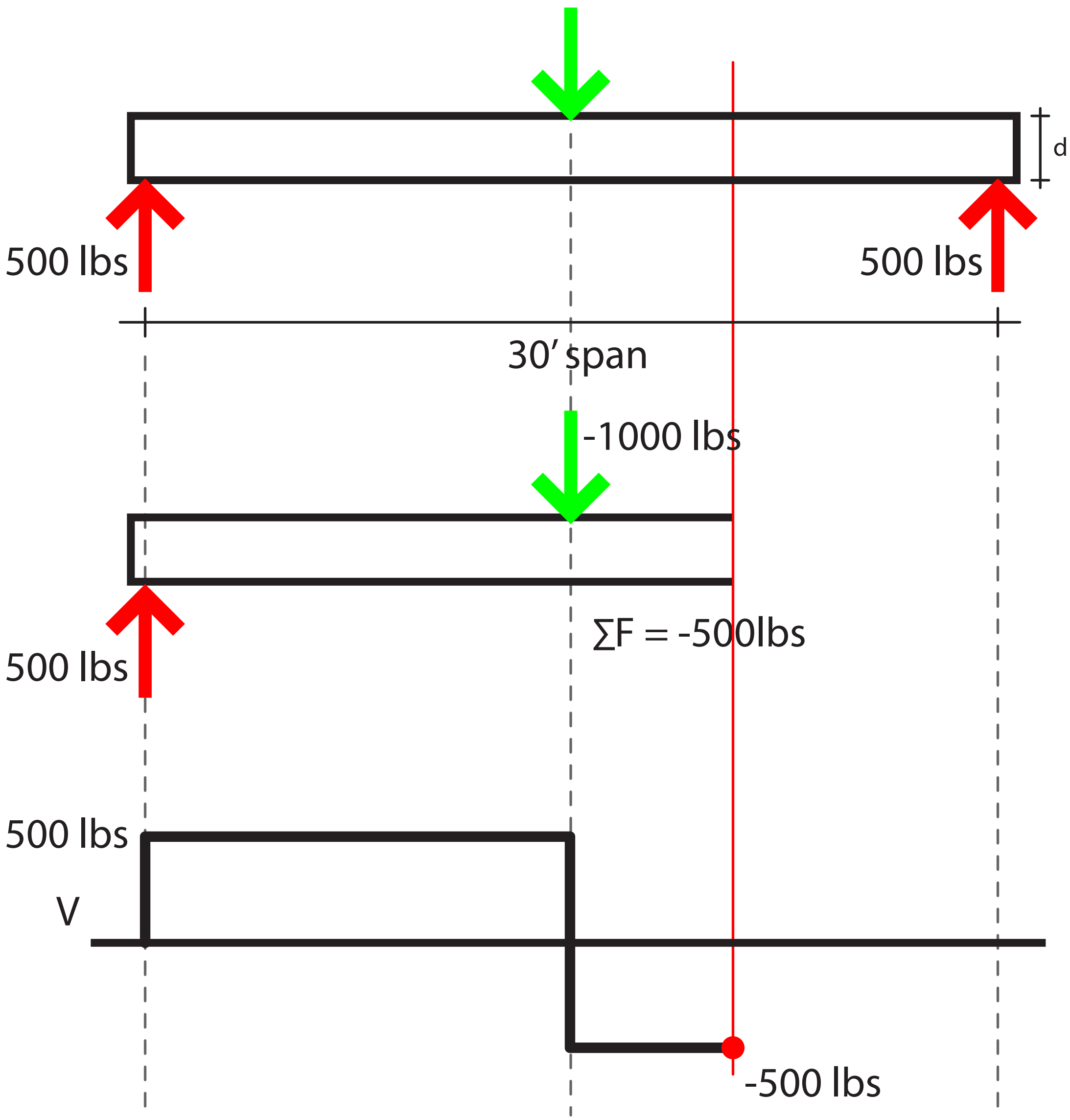

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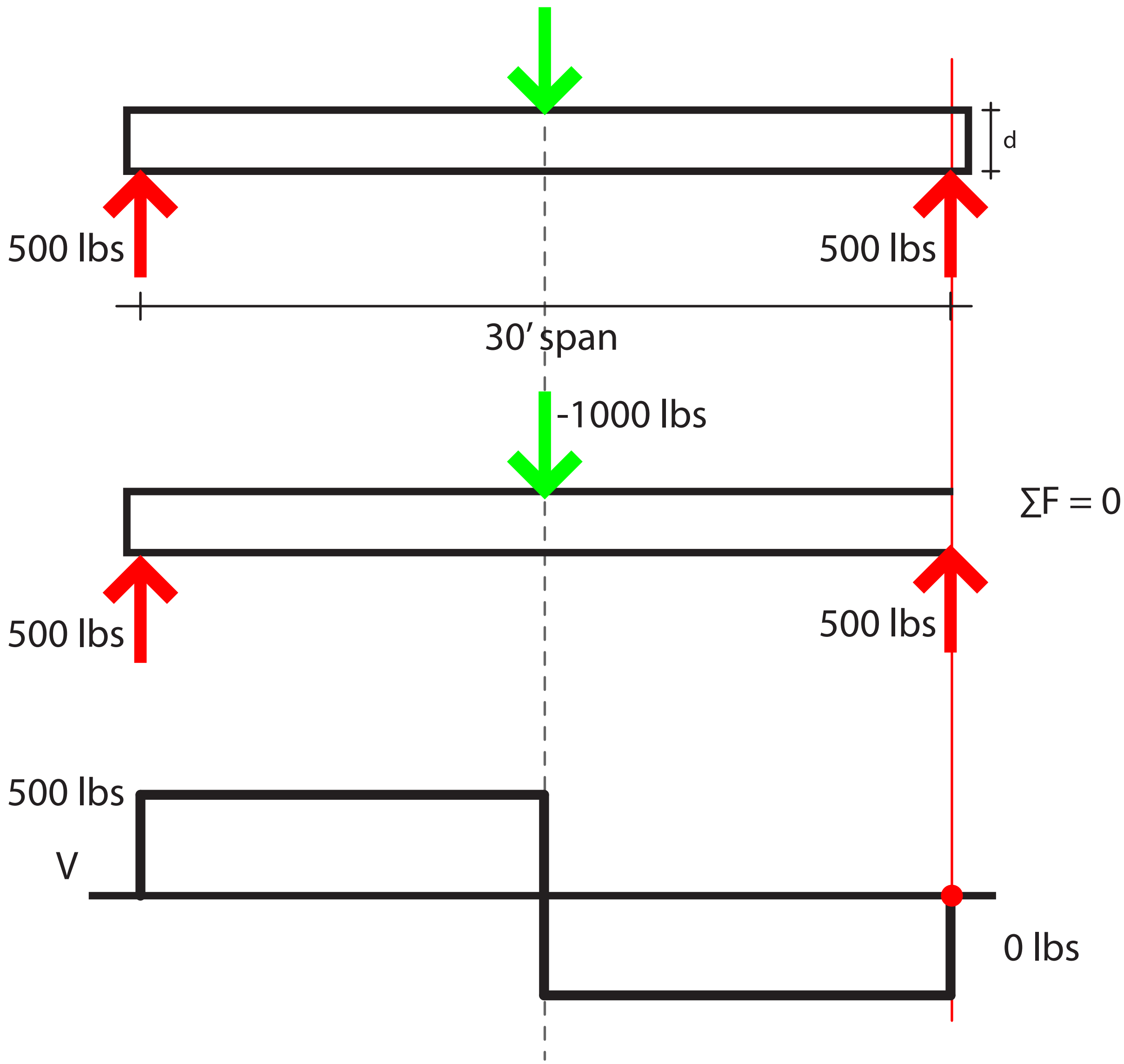
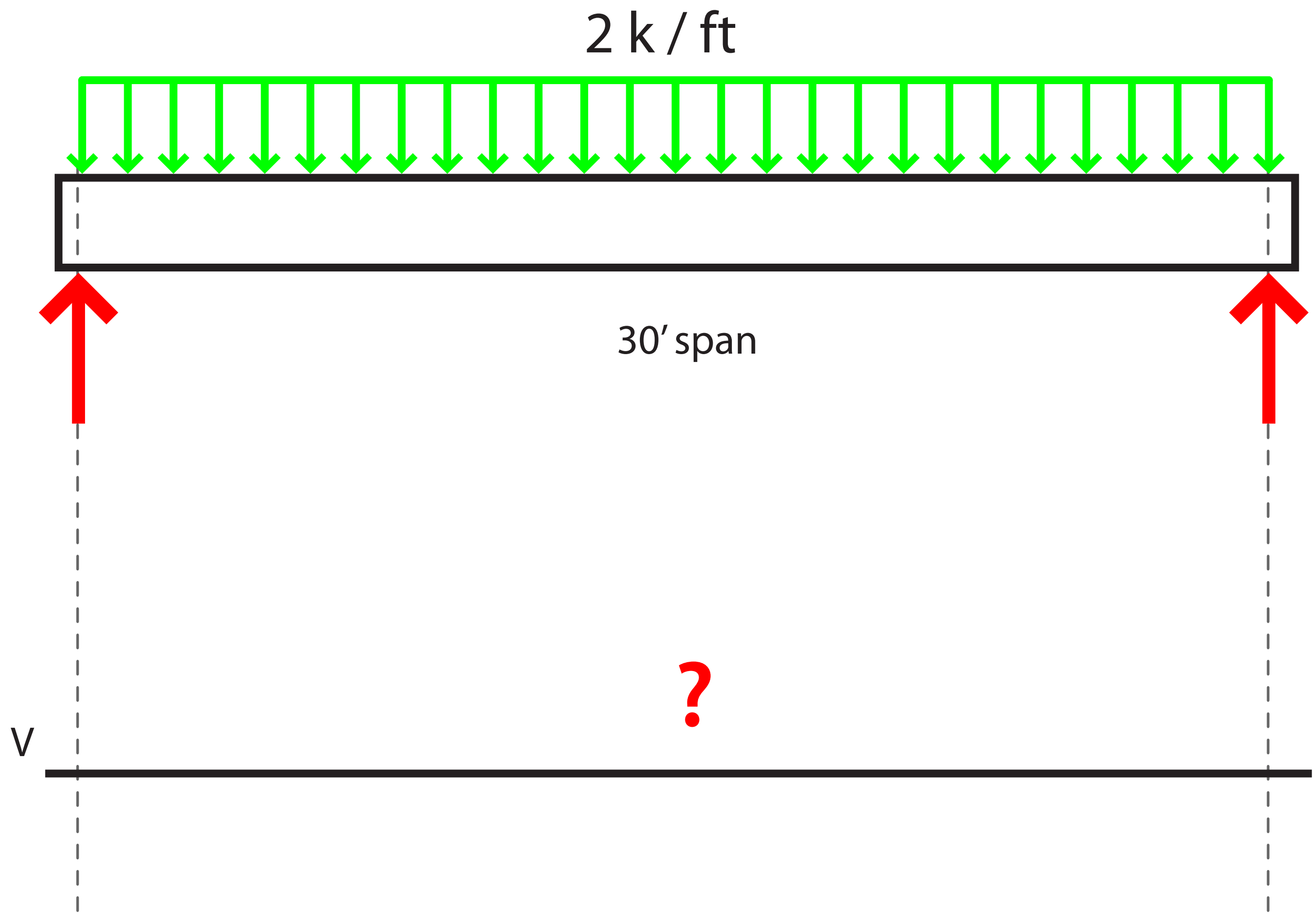


WHAT ABOUT THIS?



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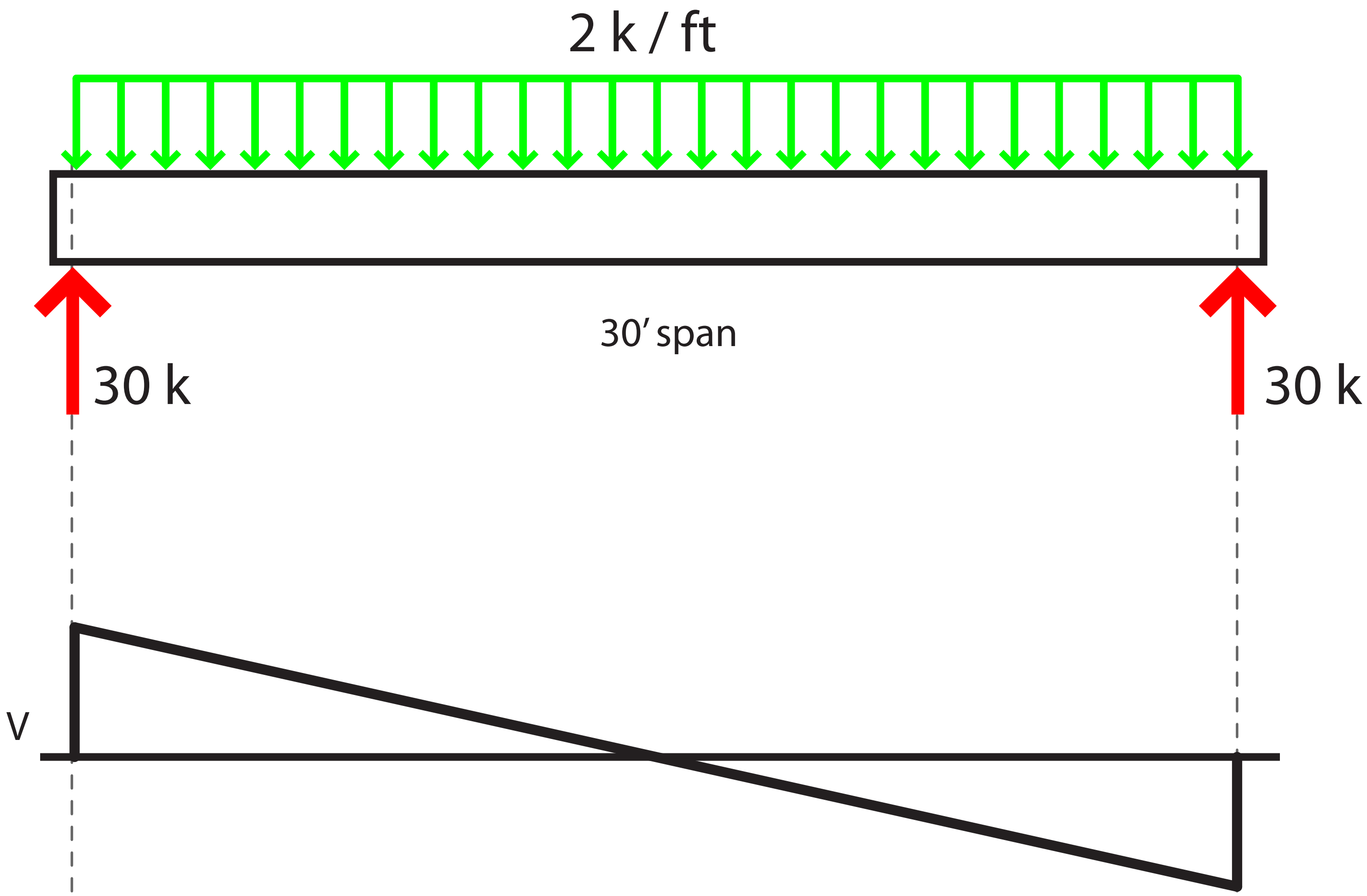
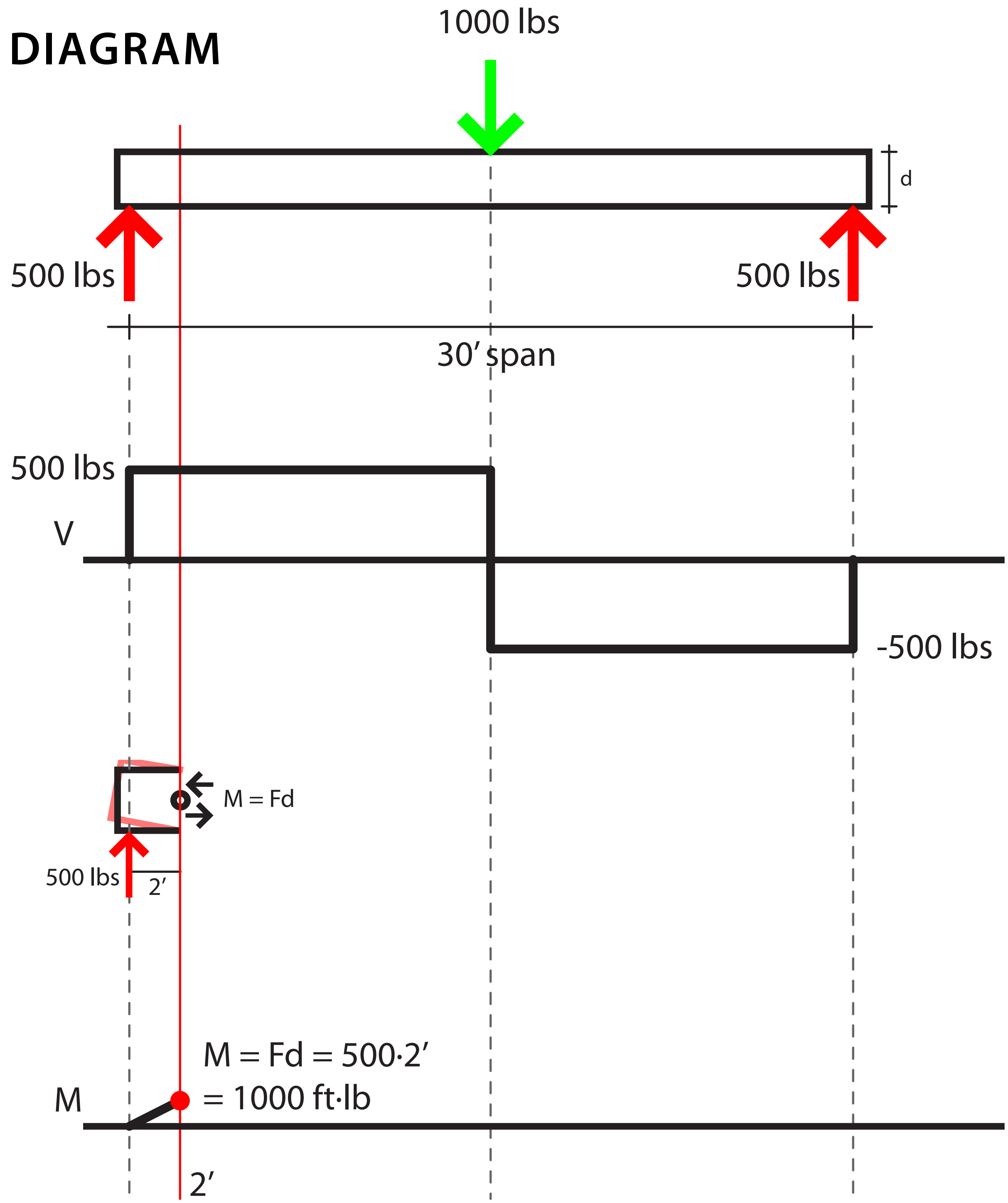


DRAWING THE MOMENT DIAGRAM



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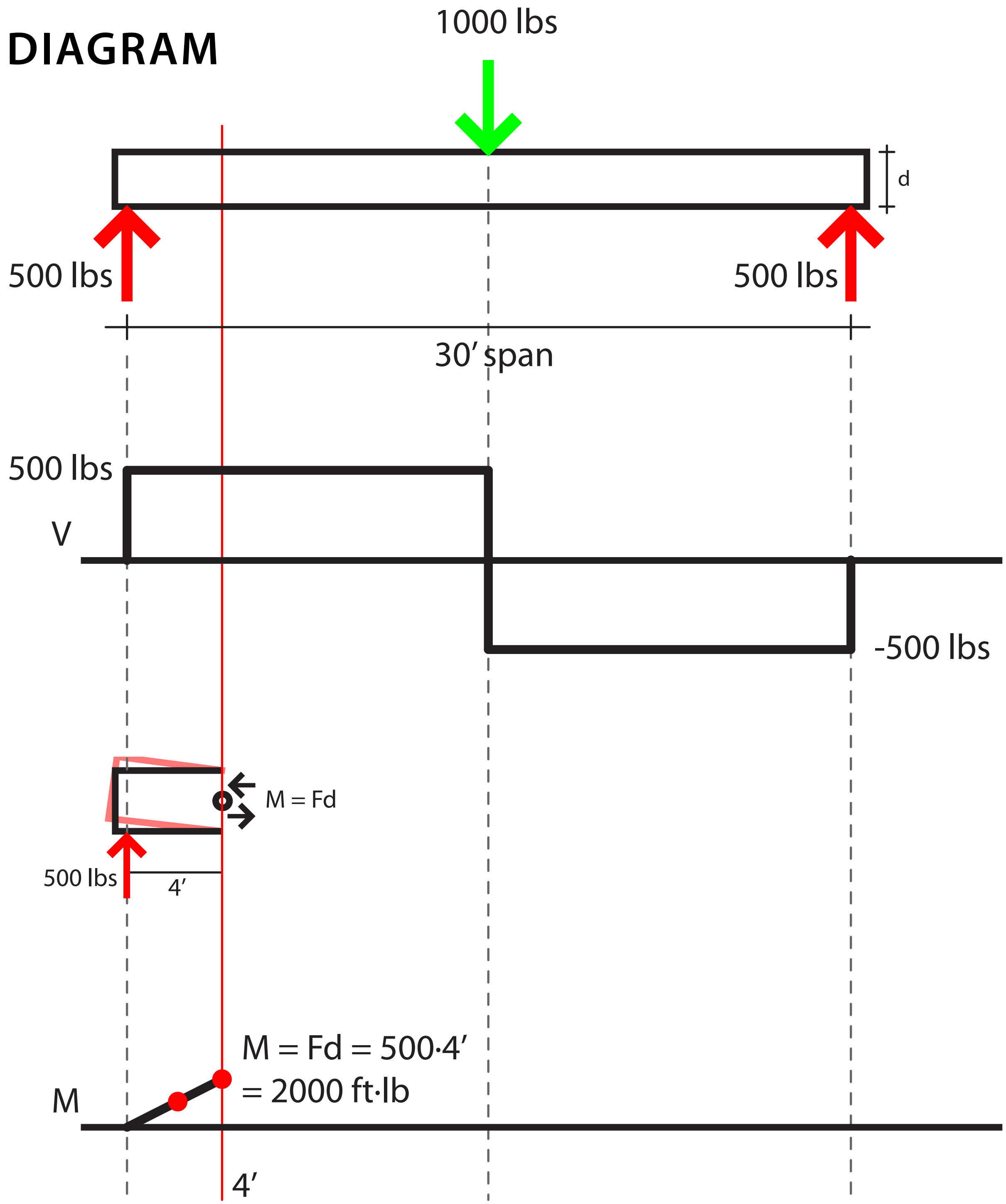

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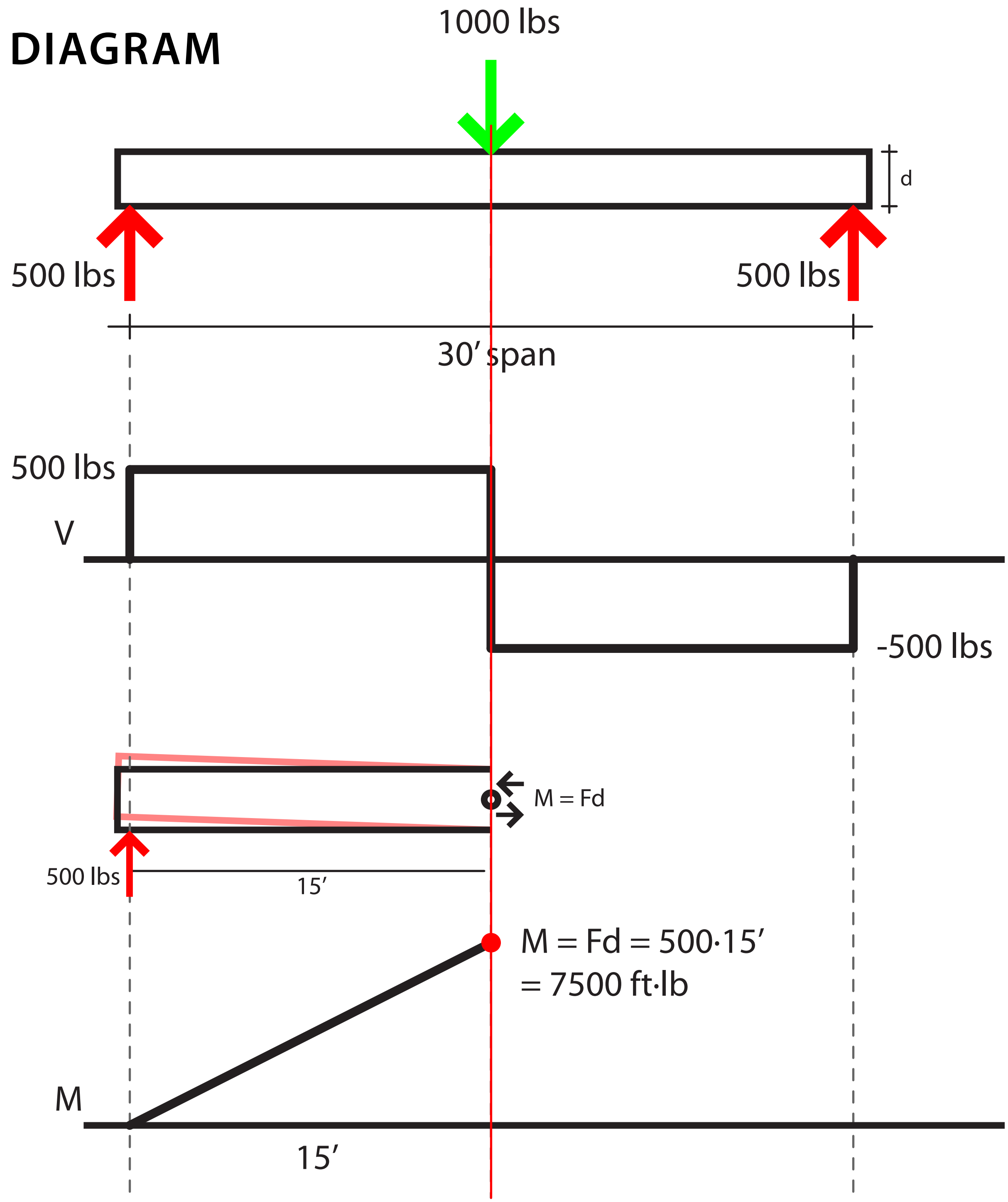

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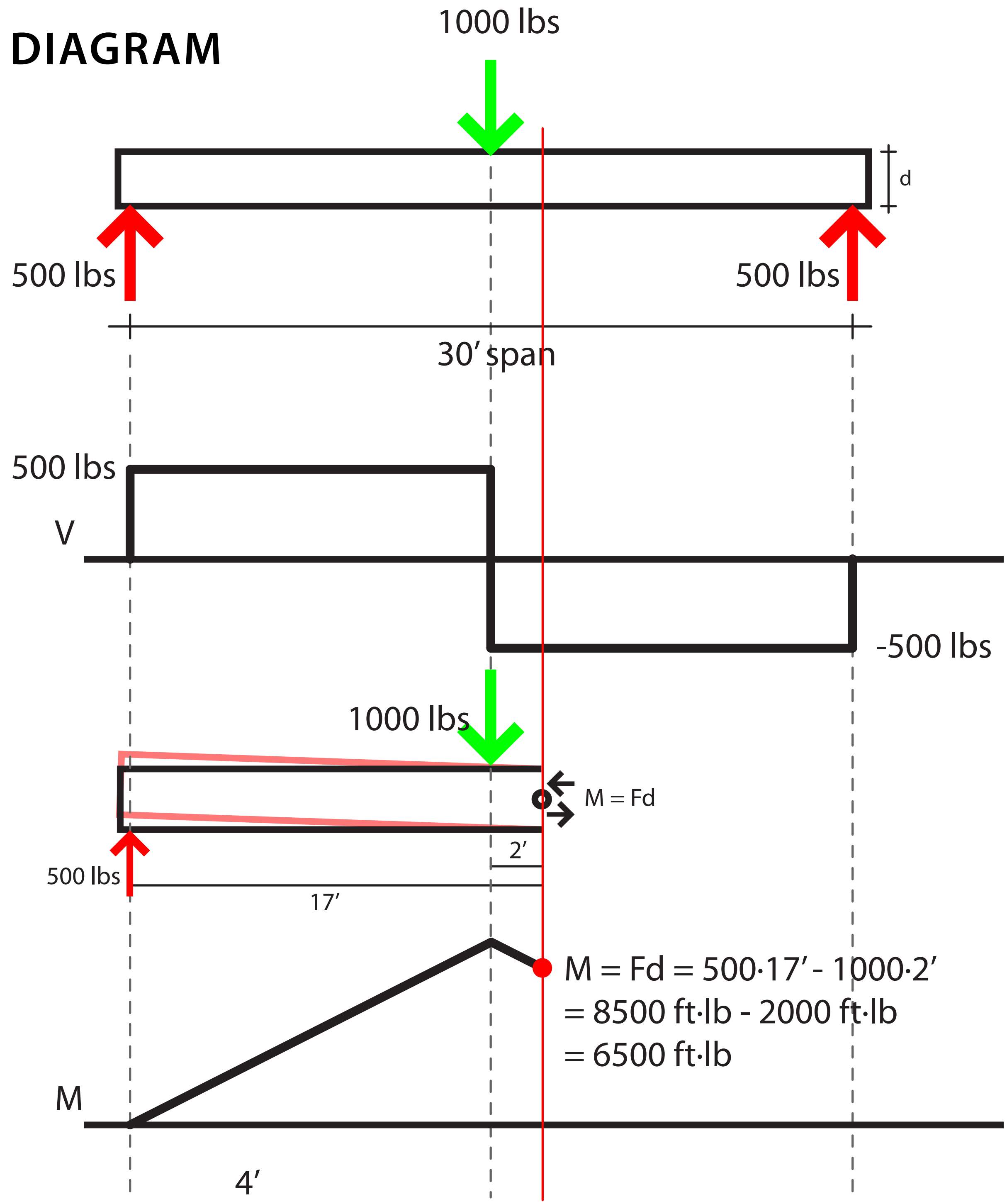
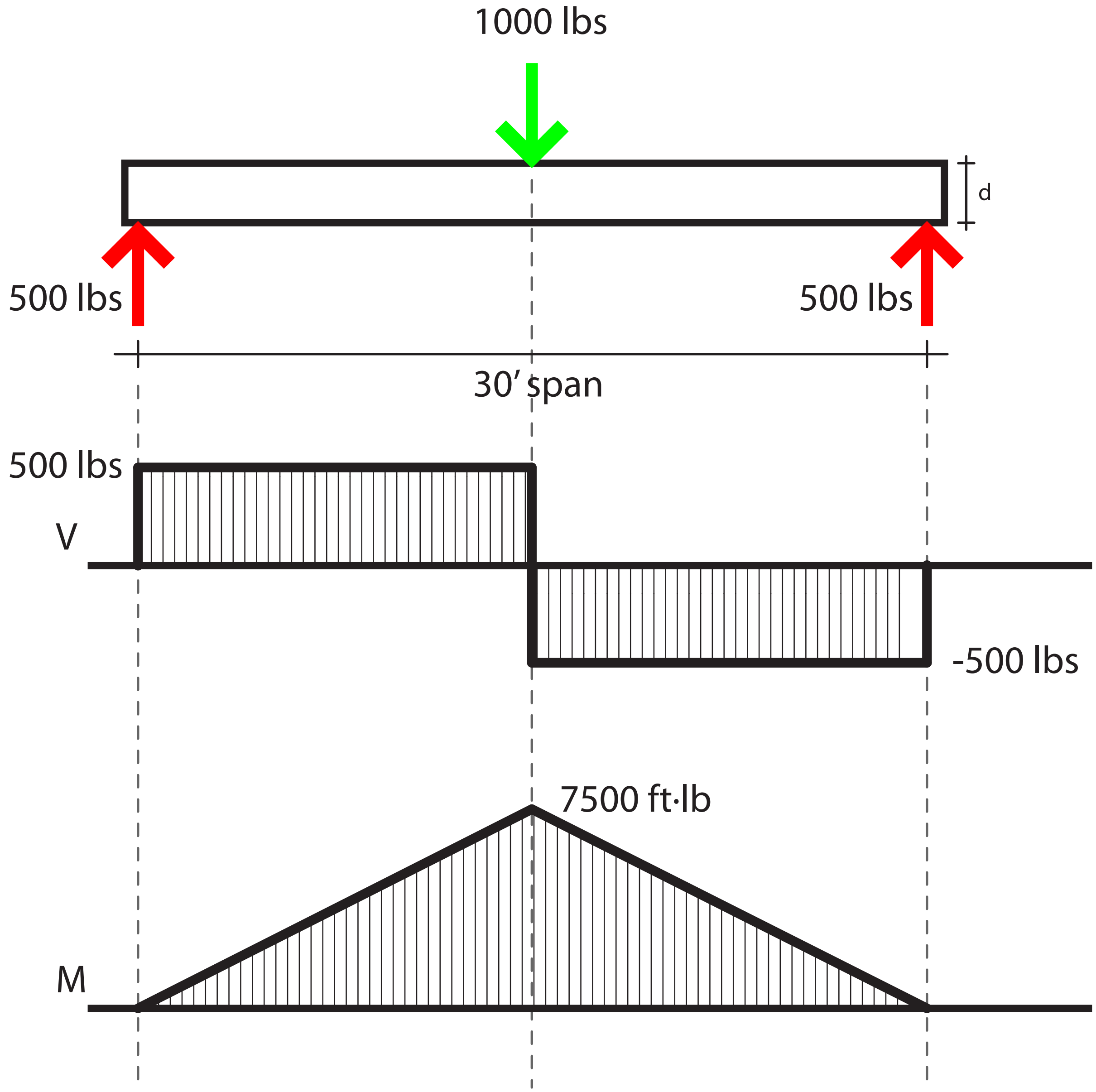


FINAL SHEAR AND MOMENT DIAGRAMS



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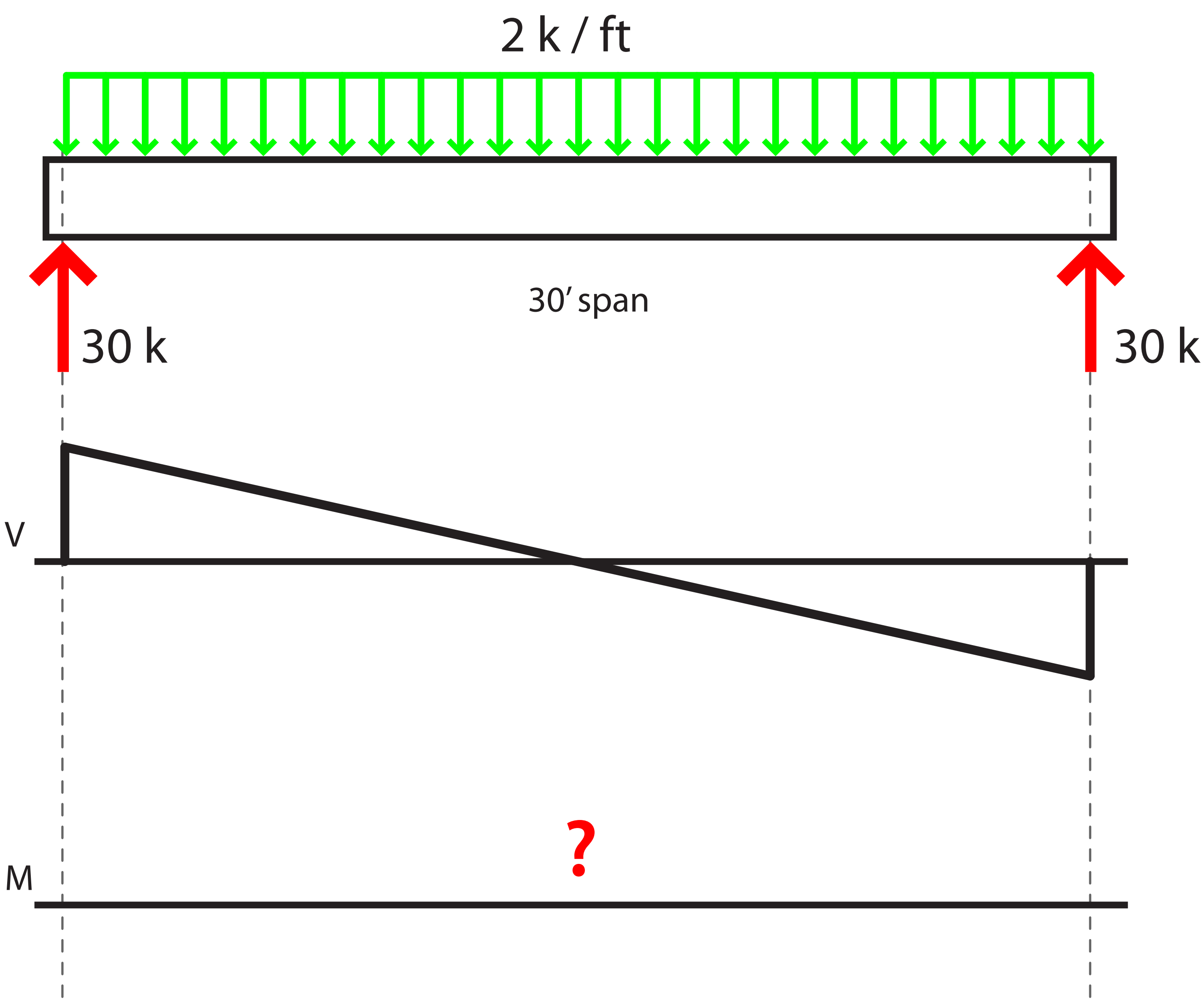

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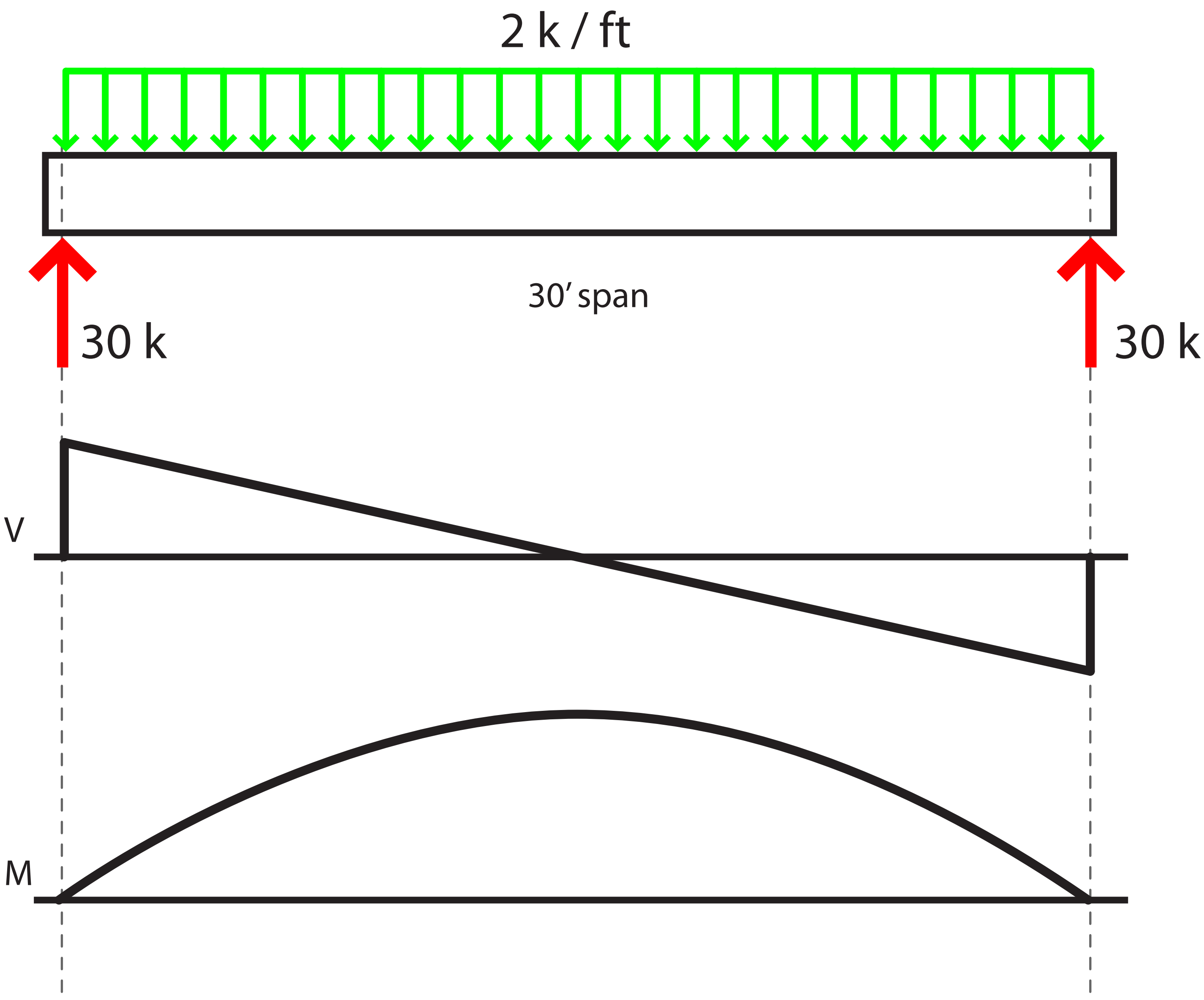

RULES FOR DRAWING SHEAR AND MOMENT DIAGRAMS

Start by drawing the free body diagram of the beam, with all loads and reactions. Drop lines at each.