FAQ's

1. What is slenderness ratio?

Slenderness ratio is a measure of how long the column is compared to its cross-section's effective width (resistance to bending or buckling). The slenderness ratio (s), is simply the column's lengthdivided by the radius of Gyration.

$$\frac{l}{k} \quad \text{i.e.} \quad \frac{\text{length of member}}{\text{least radius of gyration}}$$

Short Column: 0<I/k<60

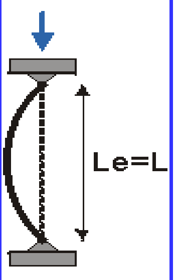
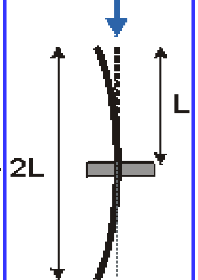
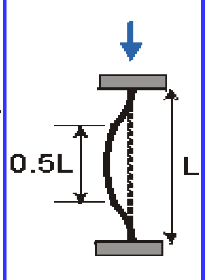
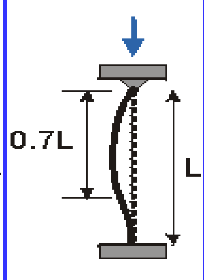
Intermediate Column: 60<I/k<120

Long Column: 120<I/k<300

2. What are the effective lengths for different end conditions?

The buckling formula for any column is given by

$$P_{cr} = \frac{\pi^2 EI}{L_e^2}$$

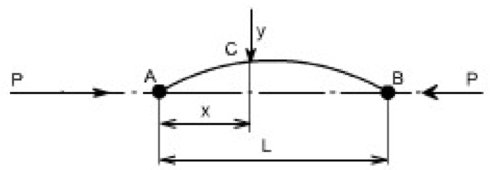
Effective Lengths for Columns with Various End Conditions				
End Condition	**Pinned-Pinned**	**Fixed-Free**	**Fixed-Fixed**	**Fixed-Pinned**
The effective length is equal to the distance between points in the column where moment = 0 (between "pins"). This occurs when the curvature of the column changes. The Fixed-Free column is "mirrored" through the fixed end to visualize L_e=2L.				
Effective Length, L_e	L	2L	0.5L	0.7L
Relative Buckling Strength (~ 1/ L_e^2) for same L	1	0.25	4	2

3. Explain the concept of Euler’s theory?

The column which fail by buckling can be analyzed by Euler's theory. Consider a column with pinned ends:

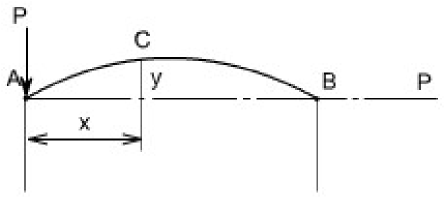
Consider an axially column , shown below, and is subjected to an axial load ‘P' this load ‘P' produces a deflection ‘y' at a distance ‘x' from one end.

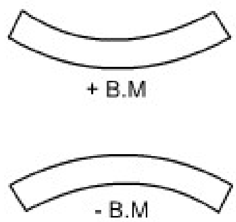
Assume that the ends are either pin jointed or rounded so that there is no moment at either end.



Assumptions:

The column is assumed to be initially straight, the end load being applied axially through centroid.





According to sign convention

$$B.M|_C = -Py$$

Futher,we know that

$$EI\frac{d^2y}{dx^2} = M$$

$$EI\frac{d^2y}{dx^2} = -P.y = M$$

In this equation ‘M' is not a function ‘x'. Therefore this equation cannot be integrated directly as has been done in the case of deflection of beams by integration method.

Thus,

$$EI \frac{d^2y}{dx^2} + Py = 0$$

Though this equation is in ‘y' but we can't say at this stage where the deflection would be maximum or minimum.

So the above differential equation can be arranged in the following form $\frac{d^2y}{dx^2} + \frac{Py}{EI} = 0$

Let us define an operator

D = d/dx

$(D^2+n^2)\ y = 0$ where $n^2 = P/EI$

This is a second order differential equation which has a solution of the form consisting of complimentary function and particular integral but for the time being we are interested in the complementary solution only[in this P.I = 0; since the R.H.S of Diff. equation = 0]

Thus y = A cos (nx) + B sin (nx)

Where A and B are some constants.

Therefore $y = A\cos\sqrt{\frac{P}{EI}}\,x + B\sin\sqrt{\frac{P}{EI}}\,x$

In order to evaluate the constants A and B let us apply the boundary conditions,

(i) at x = 0; y = 0

(ii) at x = L ; y = 0

Applying the first boundary condition yields A = 0.

Applying the second boundary condition gives

$$B\sin\left(L\sqrt{\frac{P}{EI}}\right) = 0$$

Thus either $B = 0$, or $\sin\left(L\sqrt{\frac{P}{EI}}\right) = 0$

if B=0, that y0 for all values of x hence the strut has not buckled yet. Therefore, the solution required is

$$\sin\left(L\sqrt{\frac{P}{EI}}\right) = 0 \quad \text{or} \quad \left(L\sqrt{\frac{P}{EI}}\right) = \pi \text{ or } nL = \pi$$

$$\text{or} \quad \sqrt{\frac{P}{EI}} = \frac{\pi}{L} \quad \text{or} \quad P = \frac{\pi^2 EI}{L^2}$$

From the above relationship the least value of P which will cause the strut to buckle, and it is called the "Euler Crippling Load" P_e from which w obtain.