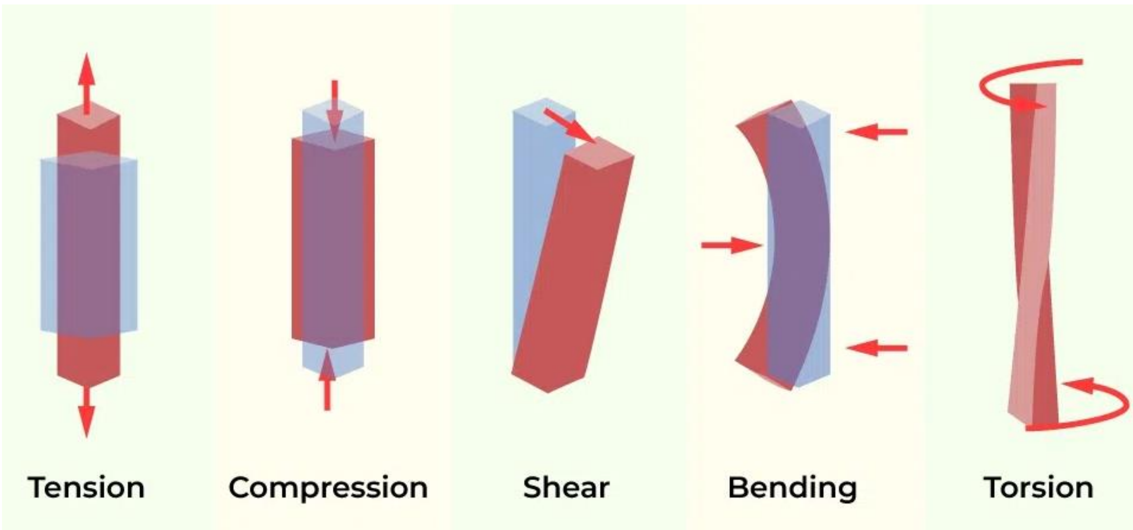
ZEAL EDUCATION SOCIETY'S ZEAL COLLEGE OF ENGINEERING AND RESEARCH NARHE │PUNE -41 │ INDIA		
Record No.: **ZCOER-ACAD/R/16H**	Revision: **00**	Date:**01/04/2021**

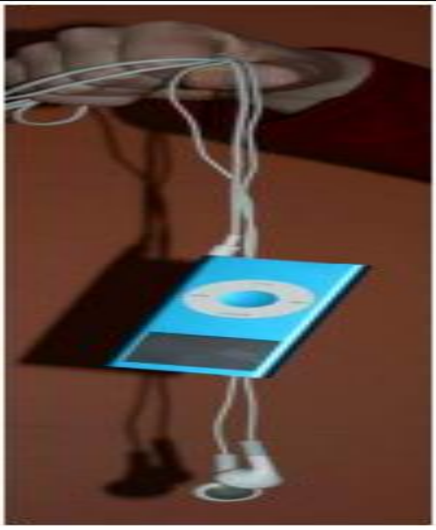
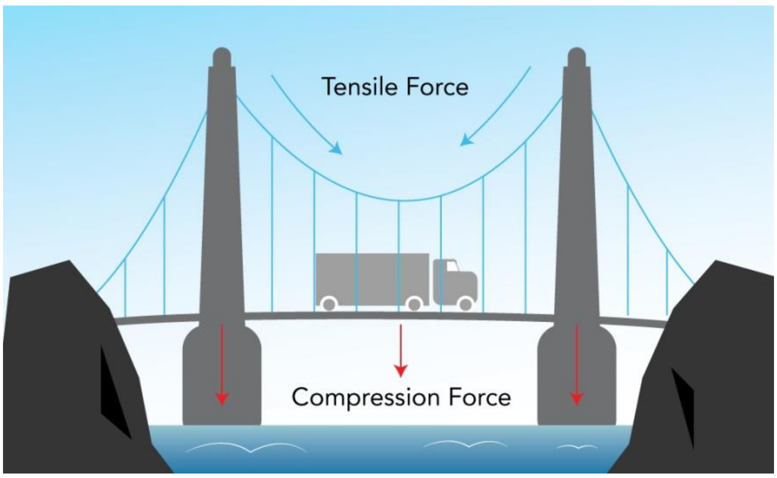
Unit Wise Real Time Applications/Live Examples

Department: Mechanical **Semester: I** **Academic Year: 2024–2025**

Class: SE **Div.: A &B**

Course: Solid Mechanics

Unit No. - Name	**Real life Applications**
Unit I: Simple stresses and strains	 **Stress and strain in Uni-axial solid and hollow bars (Tension)**

Unit No. - Name	**Real life Applications**
	 **Engage:** Take your iPod into class and dangle it by the earphone cable. Cut open the cable on an old set of earphones to expose cable and insulation **Explore:** Pass around class lengths of copper wire and lengths of empty hollow insulation and invite students to stretch them. Discuss relative extensions and stiffness. Someone will probably snap one so talk about ultimate tensile stress. Be sure have to enough lengths that every student has at least one to play with while you are talking.  Temperature stress

Unit No. - Name	**Real life Applications**
	

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Unit No. -Name	Real life Applications
Unit II: SFD & BMD	**Bending moments and shear stress diagrams for skate board**

Engage:

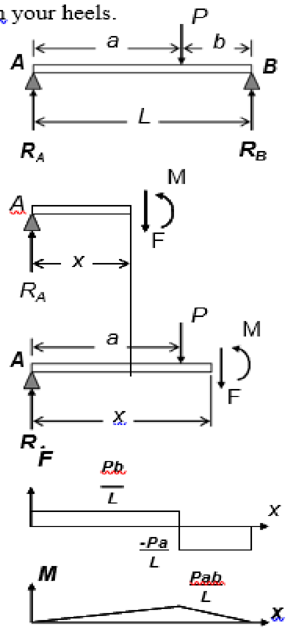
Ride a skateboard into class.

Explore:

Discuss the shear forces and bending moment's set-up in the skateboard when you stand on it sideways balanced on your heels, i.e. approximating a point load. When you stand of the board more normally, how do the shear forces and bending moments change? Discuss where you need to stand to induce a zero bending moment.

Explain:

Plot the shear force and bending moment diagrams for the case where you were rocking on your heels.



Considering the complete beam

Resolve vertically: $R_A + R_B = P$

Moments about A: $Pa - R_B L = 0$

Thus: $R_A = \frac{Pb}{L}$ $R_B = \frac{Pa}{L}$

Considering the cut section ($0<x<a$)

Resolve vertically: $F = R_A = \frac{Pb}{L}$

Moments: $M = R_A x = \frac{Pbx}{L}$

Considering the cut section ($a<x<l$)

Resolve vertically:

$F = R_A - P = \frac{Pb}{L} - P = -\frac{Pa}{L}$

Moments:

$M = R_A x - P(x - a) = \frac{Pa}{L}(L - x)$

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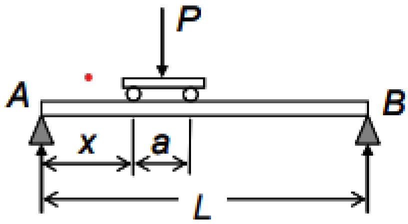
	Elaborate:

When a skateboarder crosses a plank we can determine the position at which the bending moment is a maximum. The situation can be idealized as shown below:



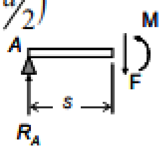
The shear force and bending moment diagrams can be plotted as previously considering small sections of beam, i.e.

Taking moments about B gives:

$$R_A L - \frac{P}{2}(L - x - a) - \frac{P}{2}(L - x) = 0$$

Thus, $R_A = \frac{P}{L}\left(L - x - \frac{a}{2}\right)$

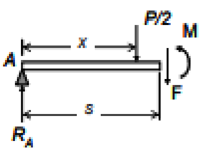
For $(s < x)$



Resolving vertically: $F = -R_A$

Taking moments: $M = -R_A s$

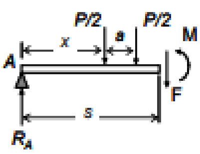
For $(x < s < (a + x))$



Resolving vertically: $F = \frac{P}{2} - R_A$

Taking moments: $M = \frac{P}{2}(s - x) - R_A s$

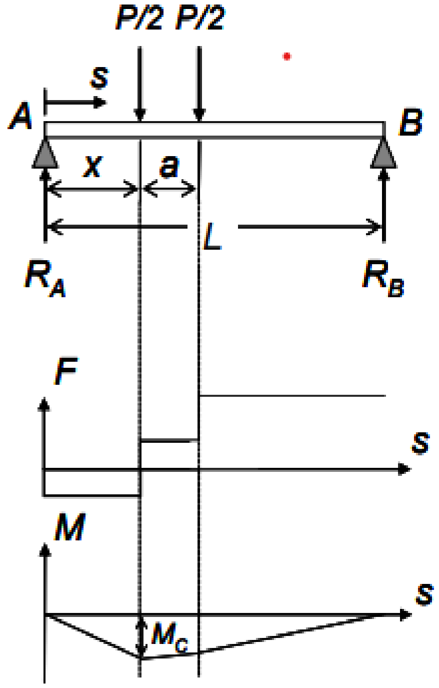
For $(s > (a + x))$



Resolving vertically: $F = P - R_A$

Taking moments:

$$M = P\left(s - x - \frac{a}{2}\right) - R_A s$$



N.B. These diagrams have been plotted assuming that $(x + a/2) > L/2$, if this were not the case then the diagrams would look slight different. The symmetry of the situation allows only this case to be considered. There are two places where M_c occurs that are symmetric about the mid-point of the beam.

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	For maximum M_C:

$$\frac{\partial M_C}{\partial x}=0 \text{ and } M_C = R_A x = \frac{Px}{2L}(2L-2x-a)$$

$$\text{So, } \frac{\partial M_C}{\partial x} = 2L-4x-a=0 \text{ and } x=\frac{L}{2}-\frac{a}{4}$$

$$\text{Thus, } \hat{M}_C = \frac{P}{2L}\left(2L-2\left(\frac{L}{2}-\frac{a}{4}\right)-a\right)\left(\frac{L}{2}-\frac{a}{4}\right)=\frac{P}{16L}(2L-a)^2$$

So for a 1.8m plank and typical skate board (a=65cm) carrying a 65kg person,

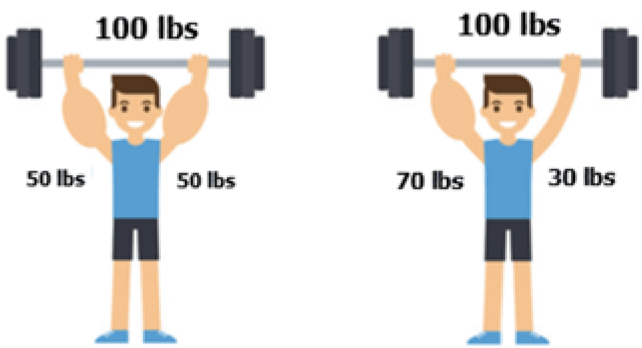
$$\hat{M}_C = \frac{65\times 9.81}{16\times 3}(3.6-0.65)^2 = 116\,\text{Nm}$$

If the plank is 13cm wide and 1.8cm thick, then the maximum bending stress is

$$\sigma = \frac{\hat{M}_C y}{I} = \frac{\hat{M}_C(h/2)}{(bh^3/12)} = \frac{6\times 116}{0.13\times 0.018^2} = 16.5\,\text{MPa}$$

This compares to compressive ultimate strengths for common woods in the range 35 to 55 MPa parallel to the grain and 4 to 10MPa perpendicular to the grain.

Bending moments and shear stress diagrams for weight lifter



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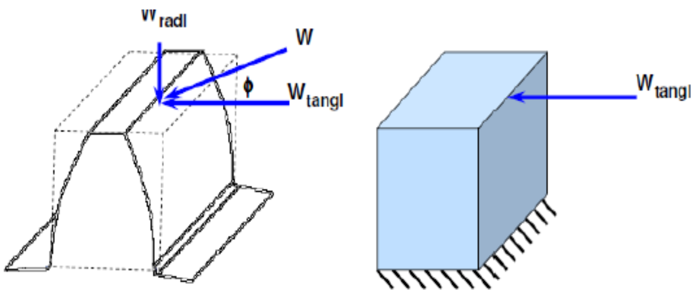
Unit No. -Name	Real life Applications
Unit III: Bending and Shear Stresses	**Examples of Bending Stresses** 1. **Portable gantry crane**  2. **Tree Bending** 

Unit No. -Name	Real life Applications
	Examples of Shear Stresses **1. Ribbon Cutting Scissors(Shear Force)**  **2. Real Life example of Shear Force**  **3. Real Life example of Shear Force** 

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<table>
<tr><th>Unit No. -Name</th><th>Real life Applications</th></tr>
<tr><td>Unit IV: Torsion of circular shafts:</td><td>

Stress and strain due to applied torque

Engage:

Enjoy a drink the evening before class, providing it has a screw top (similar to those on individual bottles airlines give you on international flights) and take the empty bottle and its top into class. Some non-alcoholic drinks have the Stelvin closure (opposite) and would allow you to offer drinks to the whole class! Other screw tops would work but the aluminum top is the simplest for analysis. Discuss the stress and strain system produced just before you break the seal when opening the bottle.

Explore:

Discuss the forces induced when opening a bottle and how the torque is transmitted from one hand to the other along the bottle as shear stress. Discuss the mode of failure in the closure. Noting that aluminum is a ductile material and thus weaker in shear than tension, thus ensuring closure remains sealed until twisted.

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Unit No. -Name	Real life Applications
	Explain: Work through the example below: Ultimate strength in shear for aluminum alloy is 240MN/m^2. So, to release the cap we need to achieve this stress level in the closure. Shear stress due to torsion, $\tau = \frac{Tr}{J}$ where T is applied torque, r is the radius at which the shear stress occurs and J is the second polar moment of area, "$J = \pi R^4/2$" and for a thin-walled tube is approximated by $J = 2\pi R^3 t$, where R is wall radius and t the wall thickness. Thus the torque required to open the bottle when R =1.2cm and t =0.1mm: $$T = 2\pi R^2 t\tau = 2\pi \times 0.012^2 \times 0.0001 \times (240 \times 10^6) = 22\,\text{Nm}$$ This is about three times the average hand-grip torque strength of an adult[4]. Perforations imply that the load bearing area is reduced by about a quarter thus reducing the torque required to =22/4=5.5Nm. **Elaborate** Consider the effect of the torque on the glass neck of the bottle, if the thickness of the glass is 3mm: $$\tau = \frac{Tr}{J} = \frac{5.5 \times 0.012}{\pi(0.024^4 - 0.018^4)/32} = 3.0\,\text{MPa}$$ Since the mean strength of soda glass is about 65MPa there is no danger of failure even allowing for a stress concentration of three in the threads of the bottle, i.e. $\tau_{max} = \tau \times SCF = 9\,\text{MPa}$. Now if the cap is damaged by a dent then it may jam and a strong person could exert three times the typical torque for an adult, i.e. about 22N then $\tau = 36\,\text{MPa}$ (including the stress concentration) – still no problem. However, if the thread on the bottle is mis-formed so that the wall thickness is reduced by 1mm <u>and</u> the cap is damaged <u>and</u> a strong adult attempts to open the bottle, then $$\tau_{max} = \frac{Tr}{J} \times SCF = \frac{22 \times 0.012}{\pi(0.022^4 - 0.018^4)/32} \times 3 = 62.4\,\text{MPa}$$ Failure is likely! This simplistic analysis ignores the presence of cracks etc. and instead focuses on using the torsion stress-strain relationships.

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Unit No. -Name	Real life Applications
Unit III: Slope and deflection of Beams , Buckling of column	**Eccentric loading**  **Explore:** Discuss the loading on the basketball pole during different types of play, e.g. • Static compression with low level bending due to offset of backboard and goal; • Additional low level bending during a goal; • Dynamic bending when the ball bounces off the backboard from a long shot plus torsion if the shot is wide; and • High level compression and bending during a slam dunk.

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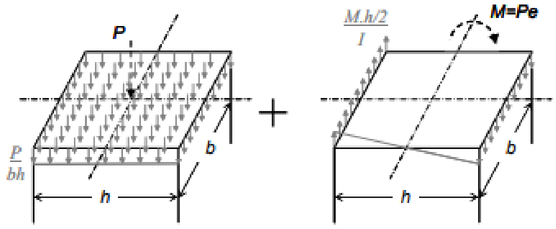
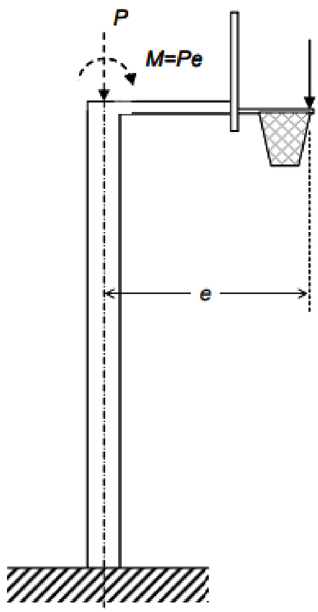
Explain:

Ask the students, working in pairs and sketching, to identify forces and moments acting about the center of the cross-section of the pole that are equivalent to the weight of a player hanging on the rim (*solid arrow*). The solution is a compressive force and a moment (*dashed arrows*).

Explain that if these two forces only produce linear elastic deformation then their effects can be added together, or superimposed. Discuss principle of superposition.





Elaborate

For a pole 10cm square manufactured from aluminum with a 60cm offset when a player hangs from the front of the ring at an effective distance from the backboard of 50cm, the maximum tensile stress in the pole occurs on the back of the pole:

Maximum tensile stress = Maximum bending stress – compressive stress

$$\sigma_{\max} = \frac{M(h/2)}{I} - \frac{P}{bh} = \frac{(Pe)h/2}{bh^3/12} - \frac{P}{bh} = \frac{6(Pe)}{bh^2} - \frac{P}{bh}$$

So, for a 90kg player, ignoring the mass of the backboard etc.

$$\sigma_{\max} = \frac{6\left(90\times 9.81\times[60+50]\times 10^{-2}\right)}{\left(10\times 10^{-2}\right)^3} - \frac{90\times 9.81}{\left(10\times 10^{-2}\right)^2} = 5827140 + 88290 = 5.9\,\text{MPa}$$

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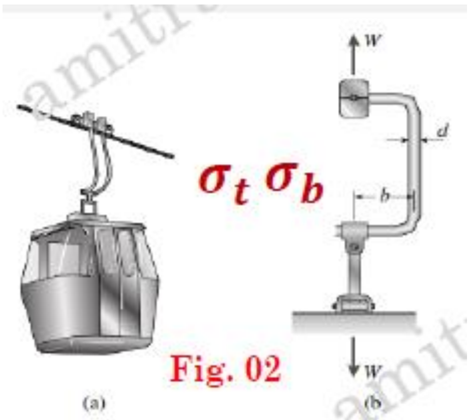
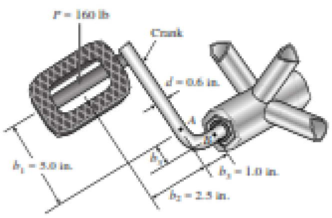
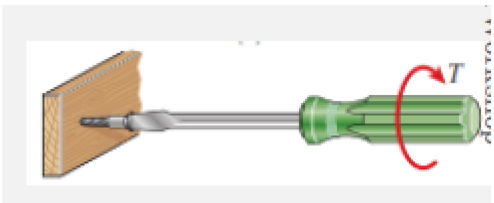
Unit No. -Name	Real life Applications
Unit VI: Combined Loading	**1) Combination of *TensionalStress*& bending stress**  Fig. 02 **2) Combination of *TensionalStress*& torsion Shear stress**  Fig. 03 **3) Combination of Bending stress, Transverse shear stress & torsion Shear stress**

Unit No. -Name	Real life Applications
	 **1) Combination of Tensile stress & torsion Shear stress** 

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