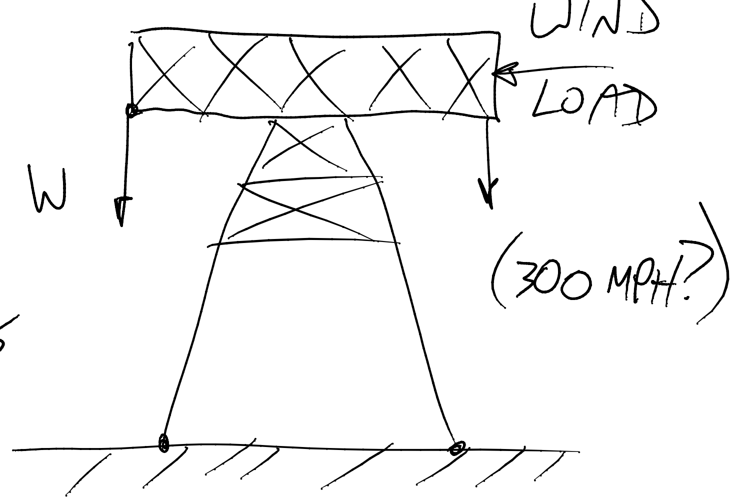
STATICS IS A WAY TO ANALYZE STRUCTURES AND MACHINES.



OBJECTIVES:

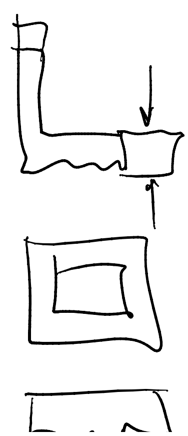
DESIGN STRUCTURE TO:

- SUPPORT WEIGHT OF WIRES
- WITHSTAND WORST-CASE WIND LOADING
- MINIMIZE VIBRATION
- DO ALL THIS WHILE MINIMIZING COST.

HOW DO WE DO THIS?

OPTION 1: BUILD A FULL-SCALE MODEL AND TEST IT. IF IT FAILS, REDESIGN AND TRY AGAIN. AND AGAIN.

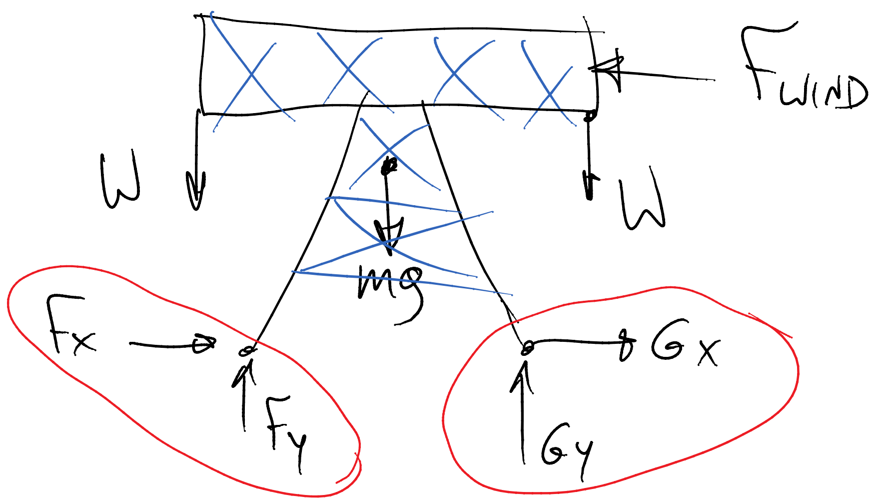
OPTION 2: DESIGN IT ON PAPER. EXAMINE EACH STRUCTURAL MEMBER USING A STATIC ANALYSIS. DETERMINE THE MEMBER THAT HAS THE MAXIMUM LOAD. USE A CROSS-SECTION THAT WILL WITHSTAND THE STRESS.



II (STRENGTH OF MATERIALS)

SPECIFY THE JOINING METHODS TO MINIMIZE COST AND LABOR (MECH. DESIGN I)

SOME AREAS OF THE STRUCTURE MAY BE TOO COMPLICATED, SO USE A FINITE ELEMENT ANALYSIS TO DETERMINE THE STRESSES AND VIBRATION CHARACTERISTICS.



UNITS

TWO UNITS SYSTEMS: S.I., ENGLISH

BASIC UNITS ARE USED TO DERIVE OTHER UNITS:

MEASURE | S.I. | ENGLISH

MEASURE	S.I.	ENGLISH
LENGTH	m	FT
MASS	Kg	SLUG OR LBM
TIME	S	S

USE NEWTON'S LAW TO DERIVE UNITS OF FORCE:

$$F = ma$$

POUND-FORCE

$$(1^{N}) = (1^{Kg})\left(1\ \frac{m}{s^2}\right), \quad (1^{LBF}) = (1^{SLUG})\left(1\ \frac{ft}{s^2}\right)$$

POUND-MASS

$$(1^{LBF}) = (1^{LBM})\left(32.2\ \frac{ft}{s^2}\right)$$

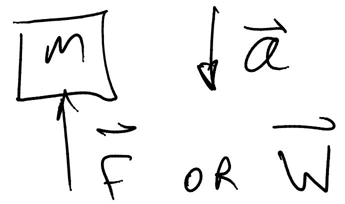
NUMERICAL CALCULATIONS

BE CONSISTENT WITH UNITS: ALWAYS CONVERT BACK TO BASIC UNITS. CARRY THE UNITS ALONG IN YOUR CALCULATIONS.

EXAMPLE

DETERMINE THE FORCE REQUIRED TO SUPPORT A MASS OF $m = 55^{Kg}$ AT A

POINT WHERE THE ACCELERATION DUE TO GRAVITY IS $a = g = 9.81 \frac{m}{s^2}$.



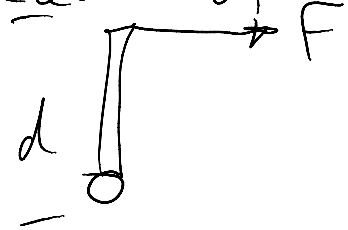
$F = ma$ OR $W = mg$

$$\boxed{W =} (55\ \cancel{kg})\left(9.81 \frac{\cancel{m}}{\cancel{s^2}}\right)\left(\frac{1\ N}{1\ \cancel{\frac{kg \cdot m}{s^2}}}\right) = \boxed{539.5\ N}$$

CONVERSION FACTORS CAN BE USED TO GO BETWEEN SYSTEMS:

CONVERT A TORQUE OF 100 FT-LBF TO N-M.

$T = F \cdot d$



$$\boxed{T =} (100\ \cancel{FT\text{-}LBF})\left(\frac{0.3048\ m}{\cancel{ft}}\right)\left(\frac{4.448\ N}{\cancel{LBF}}\right) = \boxed{135.5\ N\text{-}m}$$

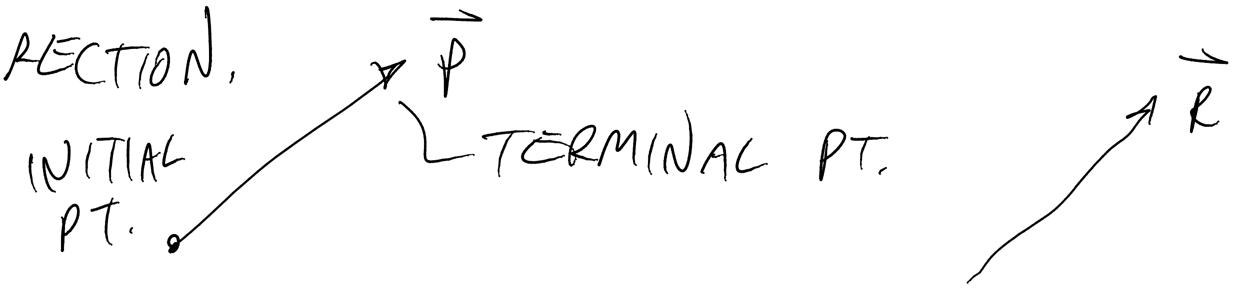
~~VECTORS~~

IN STATICS, YOU MUST BE ABLE TO MANIPULATE VECTORS IN YOUR SLEEP.

WHY ARE VECTORS IMPORTANT?

THEY CAN REPRESENT FORCES, MOMENTS, DISPLACEMENTS, VELOCITIES, ACCELERATIONS, LINEAR MOMENTUM, ANGULAR MOMENTUM, HEAT FLUX, MAGNETIC FLUX, THERMAL/NUCLEAR RADIATION, AMPERAGE, ETC.

VECTORS ARE DIFFERENT THAN SCALARS IN THAT THEY HAVE BOTH MAGNITUDE AND DIRECTION.



TWO VECTORS ARE EQUAL IF THEY HAVE THE SAME MAGNITUDE AND DIRECTION.

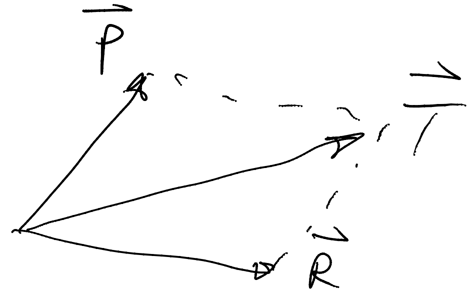
$$\vec{P} = \vec{R}$$

FREE VECTORS CAN BE TRANSLATED FROM ONE POSITION TO ANOTHER, PROVIDED THAT THE MAGNITUDE NOR DIRECTION IS CHANGED.

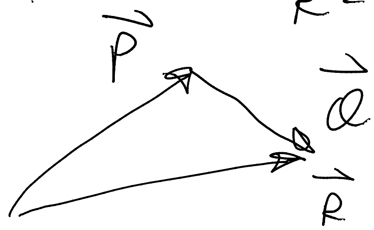
FREE VECTORS CAN BE ADDED USING THE PARALLELOGRAM LAW: $\vec{P}$

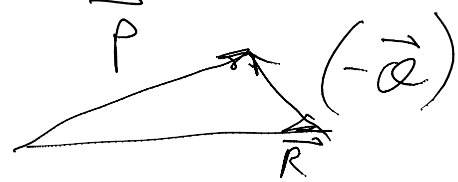
FREE VECTORS CAN BE ADDED USING THE PARALLELOGRAM LAW:

$\vec{T} = \vec{P} + \vec{R}$



SUBTRACTION: $\vec{R} = \vec{P} + \vec{Q}$ $\quad \vec{P} = \vec{R} + (-\vec{Q})$





IN THIS CLASS, YOU WILL ALWAYS RESOLVE VECTORS INTO THE RECTANGULAR COMPONENTS. THIS IMPROVES "BOOK KEEPING".

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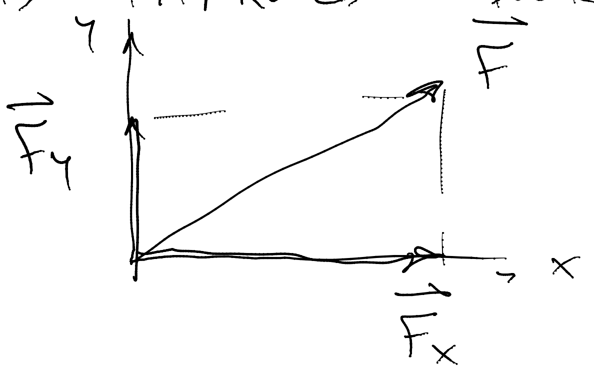
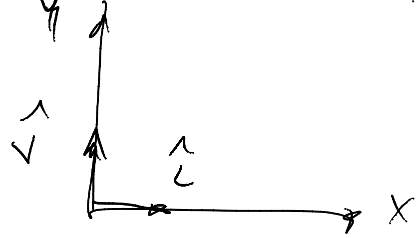


$\vec{F} = \vec{F_y} + \vec{F_x}$

THE COMPONENTS CAN BE REPRESENTED BY BY UNIT VECTORS: THE LENGTH (OR MAGNITUDE) OF A UNIT VECTOR IS 1.



DEFINITION OF SINE SHOWS

$$\sin\theta = \frac{|\vec{F_y}|}{|\vec{F}|} \quad \text{OR} \quad |\vec{F_y}| = |\vec{F}| \sin\theta$$

$|\vec{F}_x| = |\vec{F}| \cos\theta$ = SCALAR

USE UNIT VECTORS, REWRITE $\vec{F} = \vec{F}_y + \vec{F}_x$:

$\vec{F} = |\vec{F}| \cdot \cos\theta \cdot \hat{i} + |\vec{F}| \cdot \sin\theta \cdot \hat{j}$ OR

$\vec{F} = F_x \cdot \hat{i} + F_y \cdot \hat{j}$

$|\vec{F}| = \sqrt{F_x^2 + F_y^2}$ = MAGNITUDE OF $\vec{F}$

NOW WE CAN EASILY ADD THREE VECTORS:

$$\vec{R} = \vec{P} + \vec{Q} + \vec{S}$$

$$R_x \hat{i} + R_y \cdot \hat{j} = (P_x \hat{i} + P_y \hat{j}) + (Q_x \hat{i} + Q_y \hat{j}) + (S_x \hat{i} + S_y \hat{j})$$

$$R_x \hat{i} + R_y \cdot \hat{j} = (P_x + Q_x + S_x) \hat{i} + (P_y + Q_y + S_y) \hat{j}$$

FOR THE EQUALITY TO HOLD:

$R_x = P_x + Q_x + S_x = \Sigma F_x$

$R_y = P_y + Q_y + S_y = \Sigma F_y$

SUM OF THE COMPONENTS IN EACH COORDINATE DIRECTION.