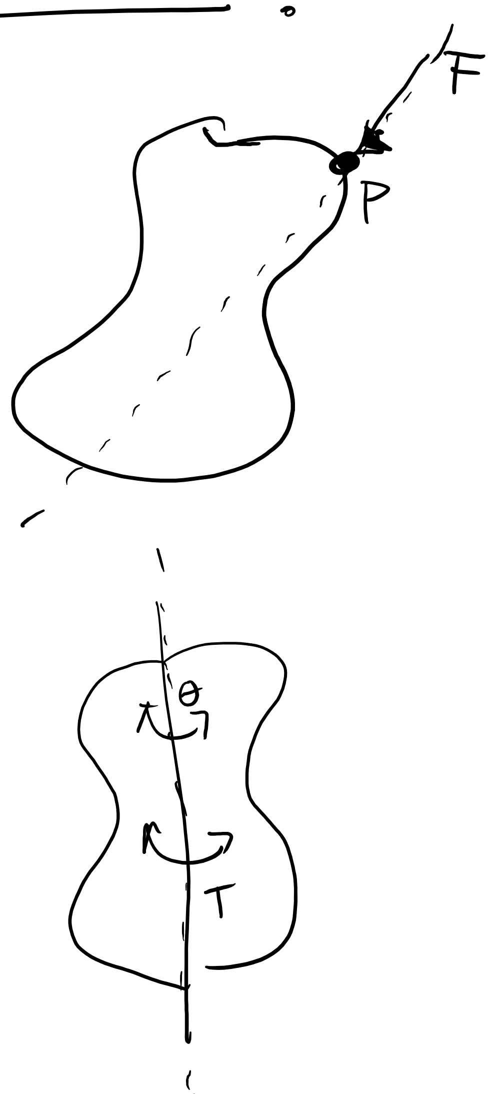
Forces and Torques (Loads)

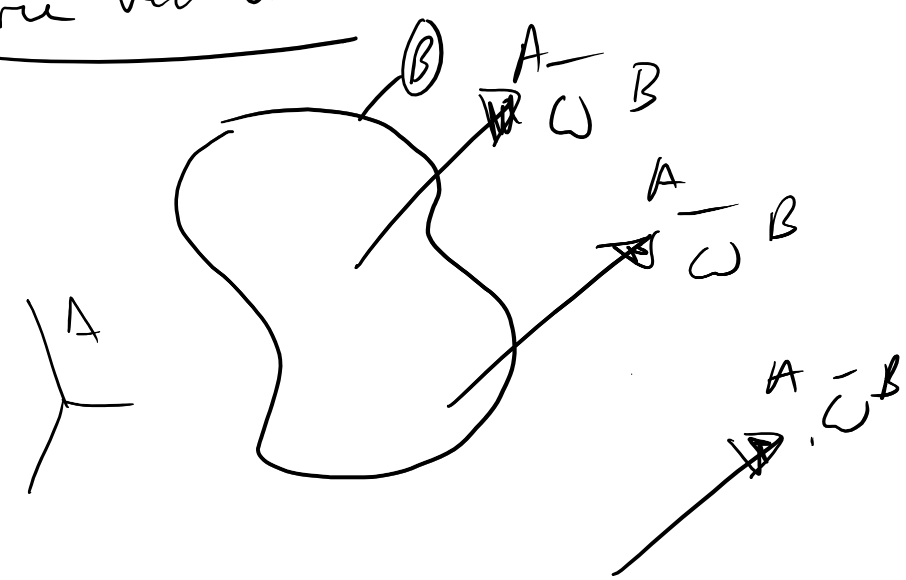
Vectors so far don't have a line of action. If a vector is associated with a line they are called **bound vectors**. If not associated w/ line: **free vectors**.

Ex

Bound

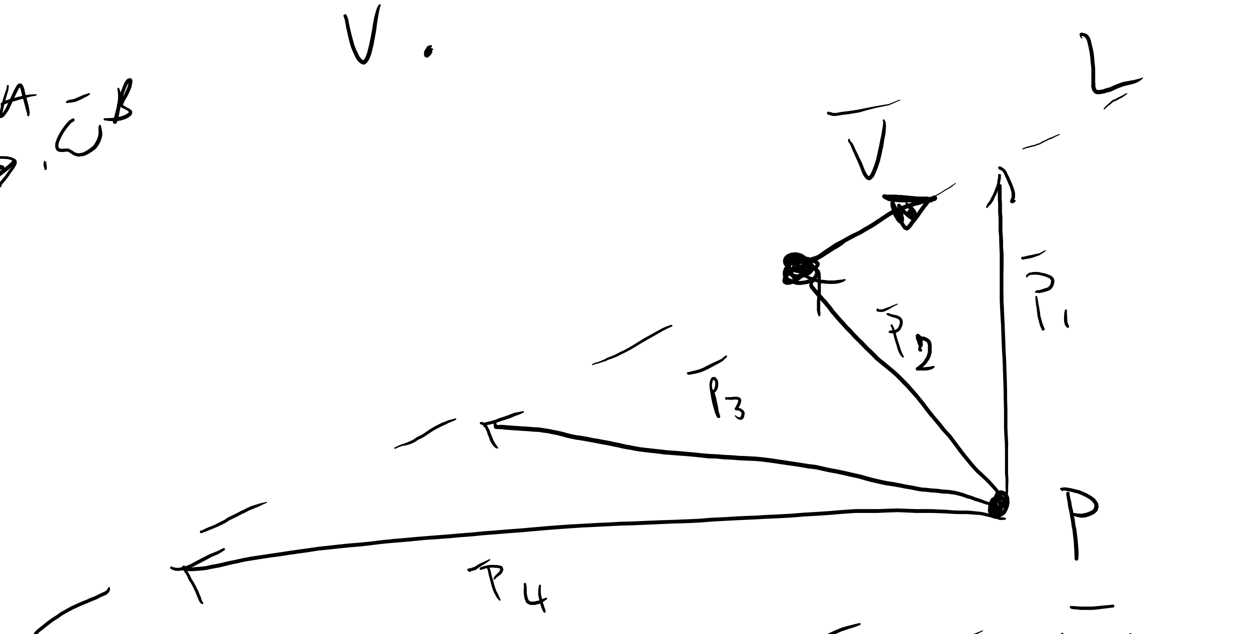


Free vector



If a vector is bound then it is possible to define its moment about some point p.

$\bar{M} \triangleq \bar{p} \times \bar{V}$ where $\bar{p}$ is a position vector from P to any other point on a line of action, L, of $\bar{V}$.



$$\bar{M} = \bar{p}_1 \times \bar{v} = \bar{p}_2 \times \bar{V} = \bar{p}_3 \times \bar{V} \ldots$$

Suppose we have a set S of vectors $\bar{V}_i$ $i=1,\dots,n$ we define the resultant of set S as $\bar{R} \triangleq \sum_{i=1}^{n} \bar{V}_i$. (bound or free)

If each of $\bar{V}_i$ are bound, sum of the moments about P is called moment of S about P.

Couple $\triangleq$ set S of bound vectors with zero resultant

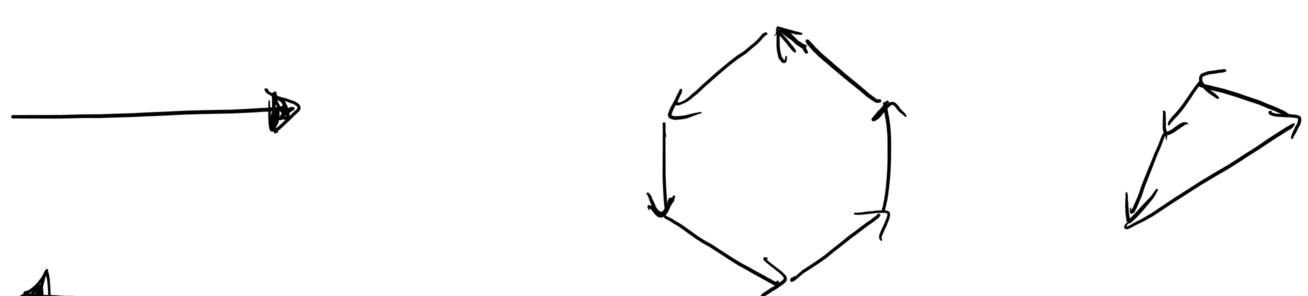
It is not a vector but a set of vectors.

Can have as many vectors as you want. $\bar{R}_S = 0$

minimum # of vectors in couple must be 2

Couple of 2 vectors: simple couple

ex:



Torque of a couple is the moment of a couple about a point. Torque of couple is the same about all points.

Equivalence Replacement

Two sets of bound vectors are equivalent when they have two properties:

1) equal resultants
2) equal moments about any point

Either set is said to be a replacement of the other.

$\equiv$

Couples having equal torques are equivalent since resultants are automatically zero and moments about every point $= T =$ torque of couple

2 equivalent sets of bound vectors have equal moments at every point since:

$$\boxed{\bar{M}^{S/P} = \bar{M}^{S/Q} + \bar{r}^{P/Q} \times \bar{R}^{S}}$$

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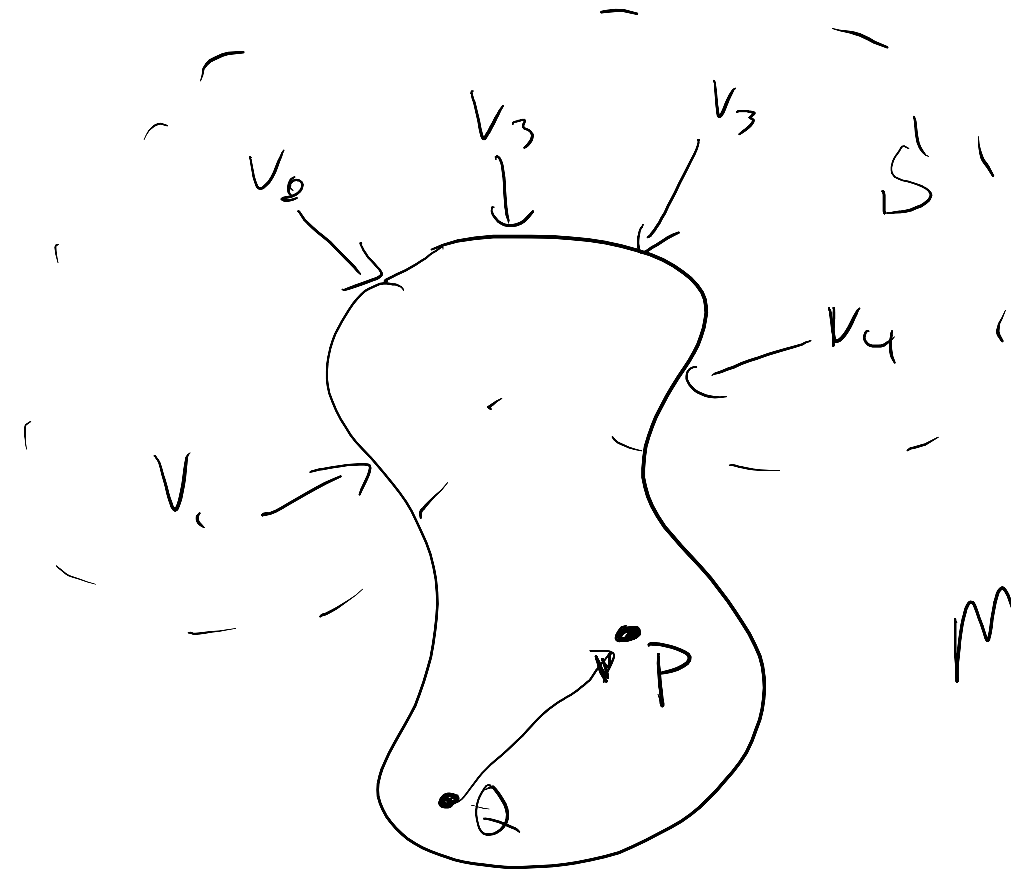
Replacement

Let S be a set of bound vectors and S' is another set of bound vectors with couple of torque T together with single bound vector $\bar{V}$ whose line of action passes through point P

Then for S' to be a replacement for S, it is necessary and sufficient that

a) $T = \bar{M}^{S'/P}$ and b) $\bar{V} = \bar{R}^{S'}$

$\therefore$ Every set S of bound vectors is equivalent to a set S' consisting of couple together with single bound vector equal to the resultant of S'.



$M^{S'/P}$

$\bar{R}^{S}$

$$\bar{M}^{S'/P} = \bar{M}^{S'/Q} + \bar{M}^{P/Q} \times \bar{R}^{S}$$