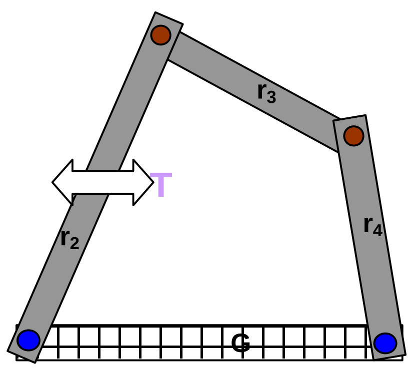
Loadings on linkages and cams:

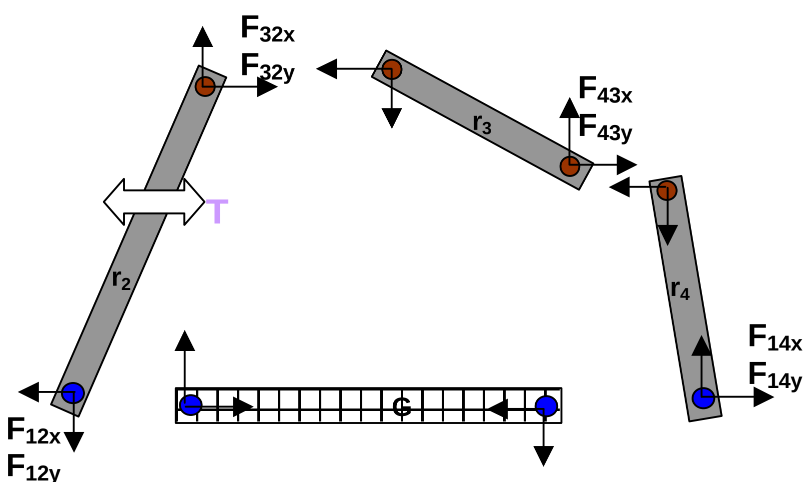
- Effective force transmission is principle concern.
- Tear out in linkage joint.
- Surface wear on cam.
- Dynamic effects on cam
    - spring force

Linkages



Links $\mathbf{r_2}$ and $\mathbf{r_4}$ rock back and forth; link **G** is the ground link (frame); link $\mathbf{r_3}$ is called the coupler link.

The loading on the link is shown below



There are eight unknown load quantities represented in the free body diagram: the pin forces at each joint. One driving force (**T**) must be given as this problem is a one degree of freedom device.

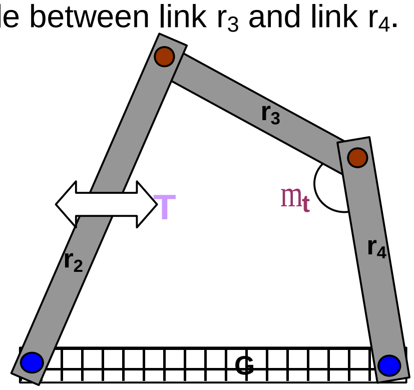
We can solve for each of the unknown forces at each position in the range of motion of the mechanism using equations of **static** equilibrium. However, using a static analysis requires that one very important assumption hold true. What is it?

Once forces are known, we can analyze for the possibility of tear out or buckling of the links at the mechanism's critical positions.

One of the critical positions can be determined very easily. It is the position of the mechanism where no further motion is possible. Some devices, called **crank-rockers** have a full range of motion, i.e., the **crank (link r_2)** can rotate 360°. However the device shown is not such a device. The device represented will be unable to move any further when the **transmission angle** reaches either 0° or 180°.

What is the transmission angle and how do we determine it?

The **transmission angle is the angle between the "pushing link" and the output link, i.e., the pushed lin**k. For example, r_2 is the driving link in the mechanism shown. Link r_3 pushes link r_4, the output link. So, the transmission angle, μ_t, is the angle between link r_3 and link r_4.



The transmission angle is a measure of how effectively the mechanism is transmitting force.

Remember this equation: $\vec{r} \; x \; \vec{F} = |r||F|\sin(m_T)$?

The closer to 90° μ_t is, the better the force transmission.

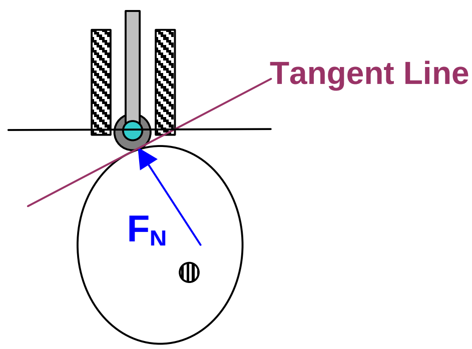
On the 4-bar device we are studying today, **r**, the moment arm, is link r_4, i.e., the force acting through link r_3 is trying to rotate link r_4 about the joint connecting r_4 to ground.

Isn't it true that the moment arm **r** will always have magnitude $\mathbf{r_4}$? You can see that if μ_t varies much from 90°, **F** will have to become increasingly larger and larger in order to drive link r_4 about its rotation axis. Engineers try to design mechanisms of this type so that the transmission angle does not ever become smaller than 50° or larger than 130°.

We can also analyze the effectiveness of force transmission in cams using the transmission angle.

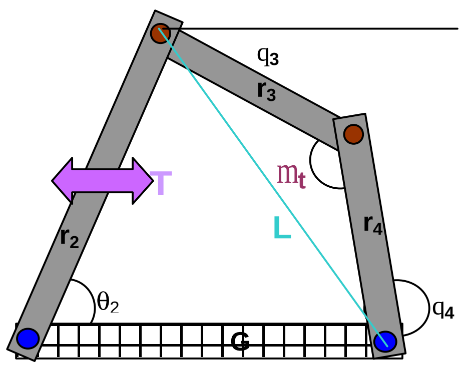
In this example, there is a roller follower being driven by the cam. The roller is constrained to follow a straight line path. The normal force, $\mathbf{F_N}$, is acting through the cam at the surface to push the roller at the point of contact. Where is the roller's moment arm? Where is its axis of rotation?

Can you add the transmission angle to the figure shown below and estimate its value?



In class assignment:

Use the notation given in the figure below and derive an expression for the crank angle that will tell you when the mechanism will be unable to effect enough force through link 3 to push link 4 any further. Hint: **use line L and the law of cosines.**



For the oscillating cam-follower system shown below, draw the transmission angle.