Sizing the Cam

- The pressure angle is the angle between the direction of motion of the follower and the direction of the axis of transmission. (0 to 30° is typically desired)
- The eccentricity (ε) is the perpendicular distance between the follower's axis of motion and the center of the cam

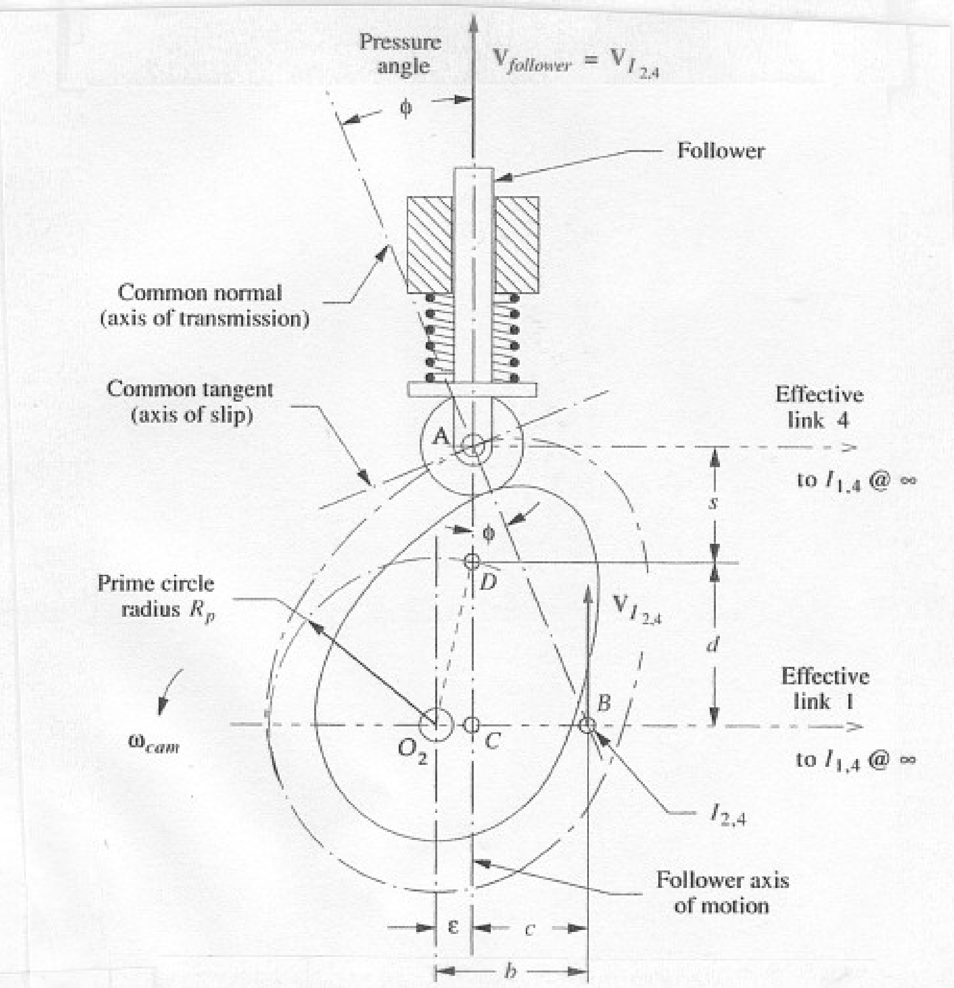
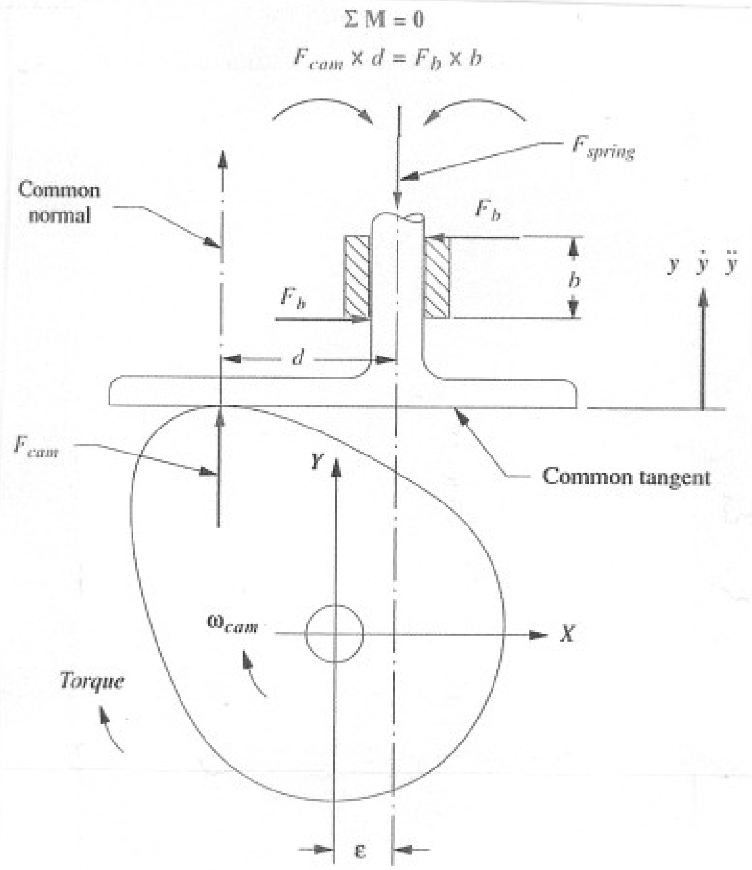


FIGURE 8-45
Geometry for the derivation of the equation for pressure angle

If a small enough cam can not be obtained having an acceptable pressure angle, then eccentricity can be introduced to change the pressure angle. The eccentricity may decrease the pressure angle on the rise but it will increase it on the return (and vice versa).

- For a flat face follower the pressure angle is always zero, however the force located away from the axis of follower travel will induce a moment that can generate friction and jam the follower.



- Here is a problem in which the radius of curvature of the follower is larger than the minimum concave radius of the cam. The follower can not generate the motion that the cam dictates because it is too big.

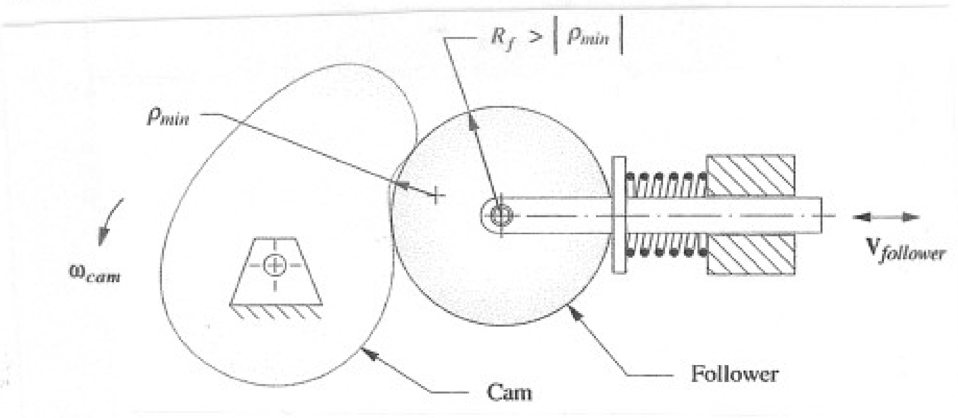


FIGURE 8-48

The result of using a roller follower larger than the one for which the cam was designed

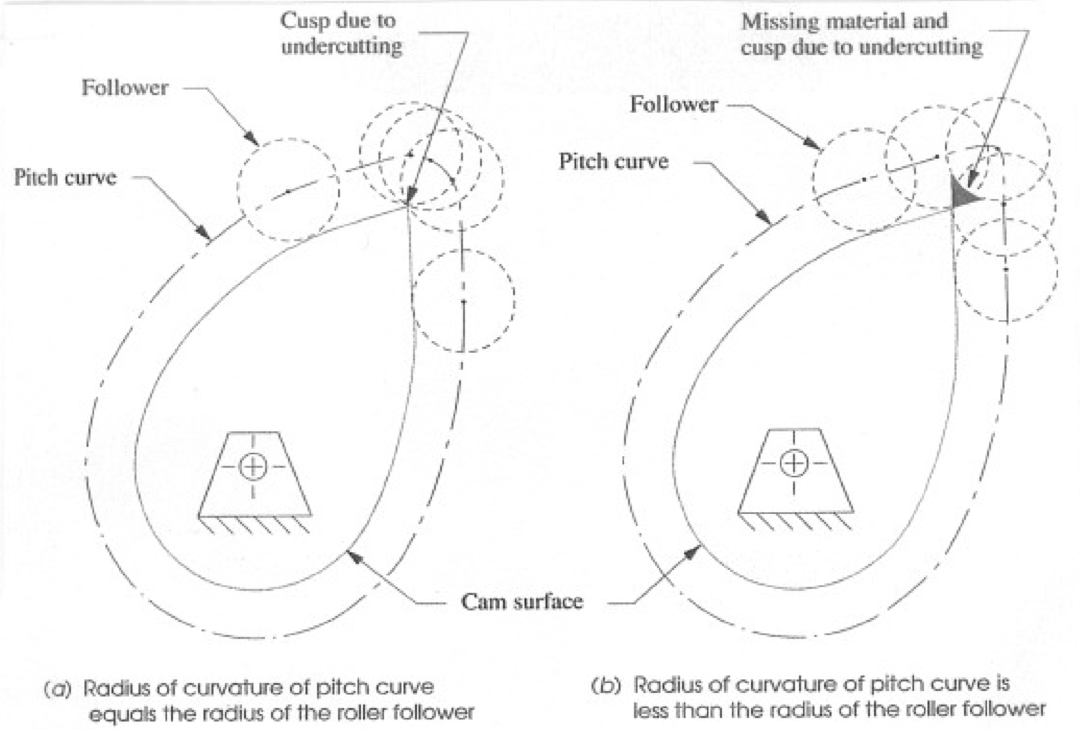


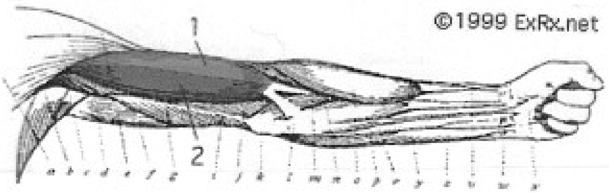
FIGURE 8-49
Small positive radius of curvature can cause undercutting

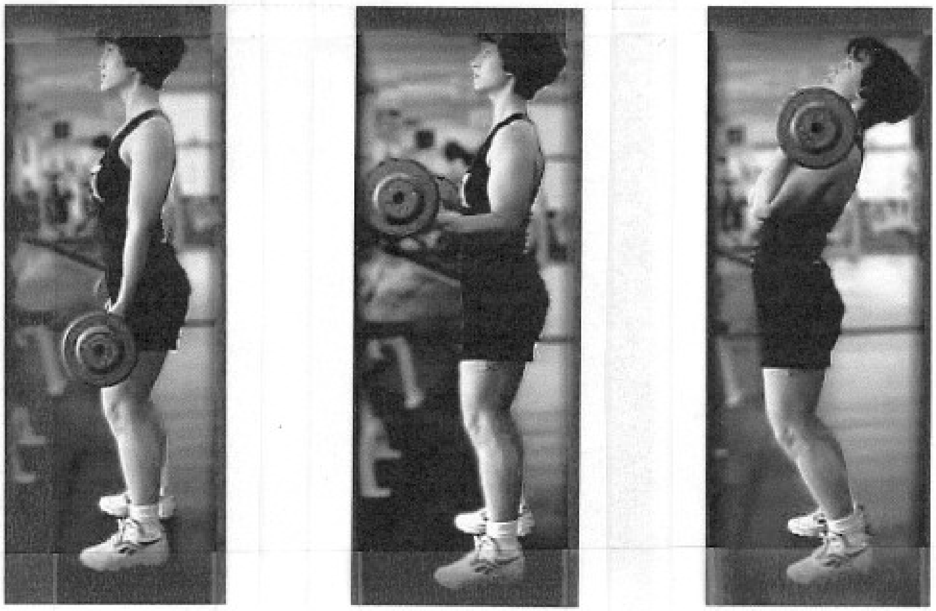
- Also when the follower radius is larger than the smallest positive (convex) local radius on the cam (or pitch curve), undercutting will occur. In figure (a) a cusp is created and the cam will not run smoothly. In figure (b) there is a cusp and material missing; the cam will not be able to reproduce the desired motion of the pitch curve.
- As a rule of thumb keep the minimum radius of curvature of the cam pitch curve at least 2 to 3 times as large as the radius of the roller follower.

Dumbell Curl Example

Consider the torque required to perform a dumbell curl exercise. When the weight is fully lowered the amount of torque or force is low. Then when the elbow reaches an angle of 90°, the torque or force is maximum.

Finally when the elbow is at approximately the fully upright position, the torque or force is low again.

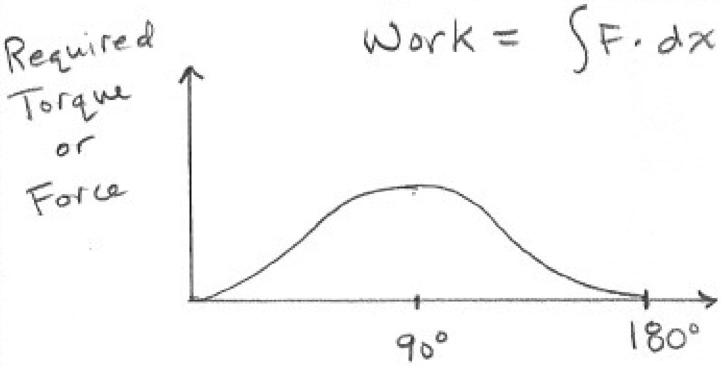


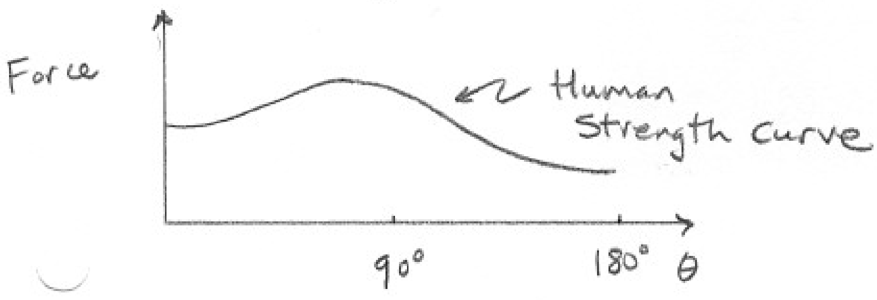


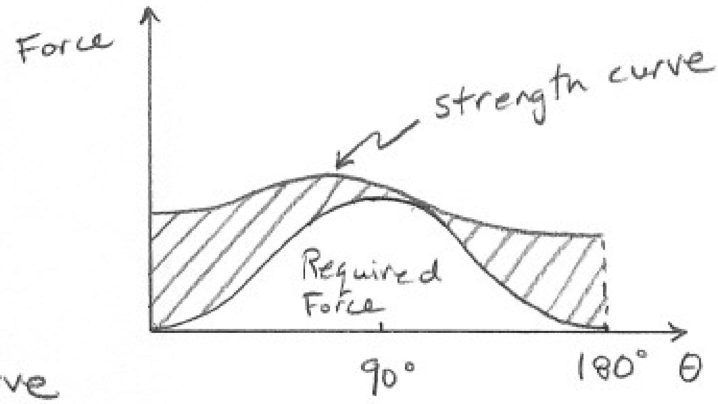
0° 90° 180°

Note the poor lifting technique in the third photograph!

$$\text{Work} = \int F \cdot dx = \int T \cdot d\theta$$

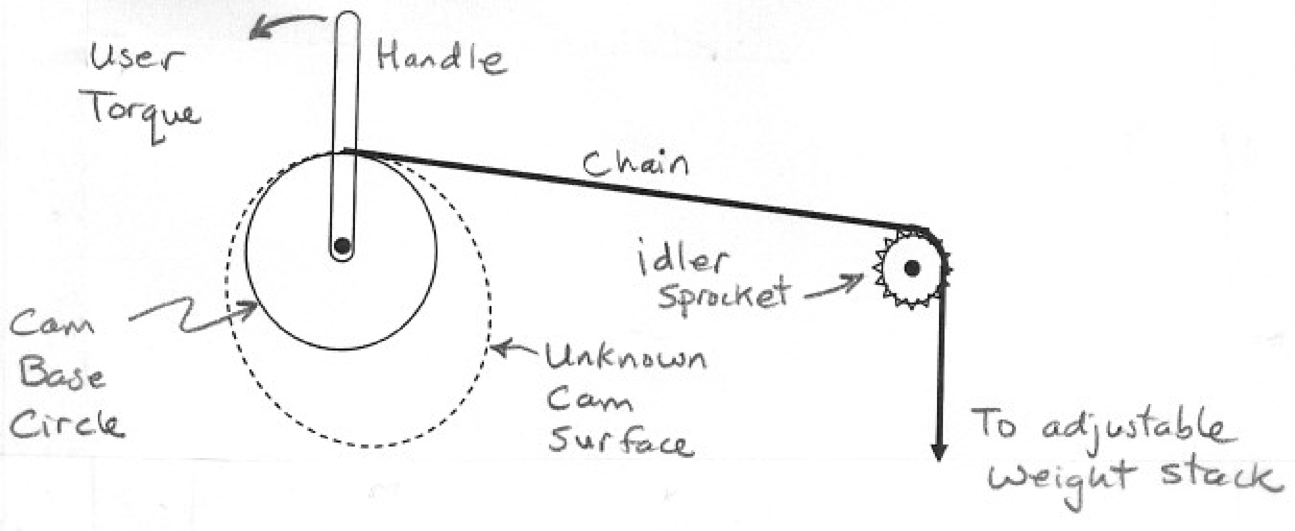


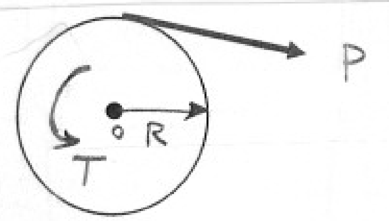




The shaded region represents the work the muscle could have done during the exercise. ∴ Not as efficient a workout!

The goal is to match the required force to the human 6-5 strength curve for a bicep curling exercise.





$\circlearrowleft + \ \Sigma M_o = T - RP = 0 \ \rightarrow \ T = RP$

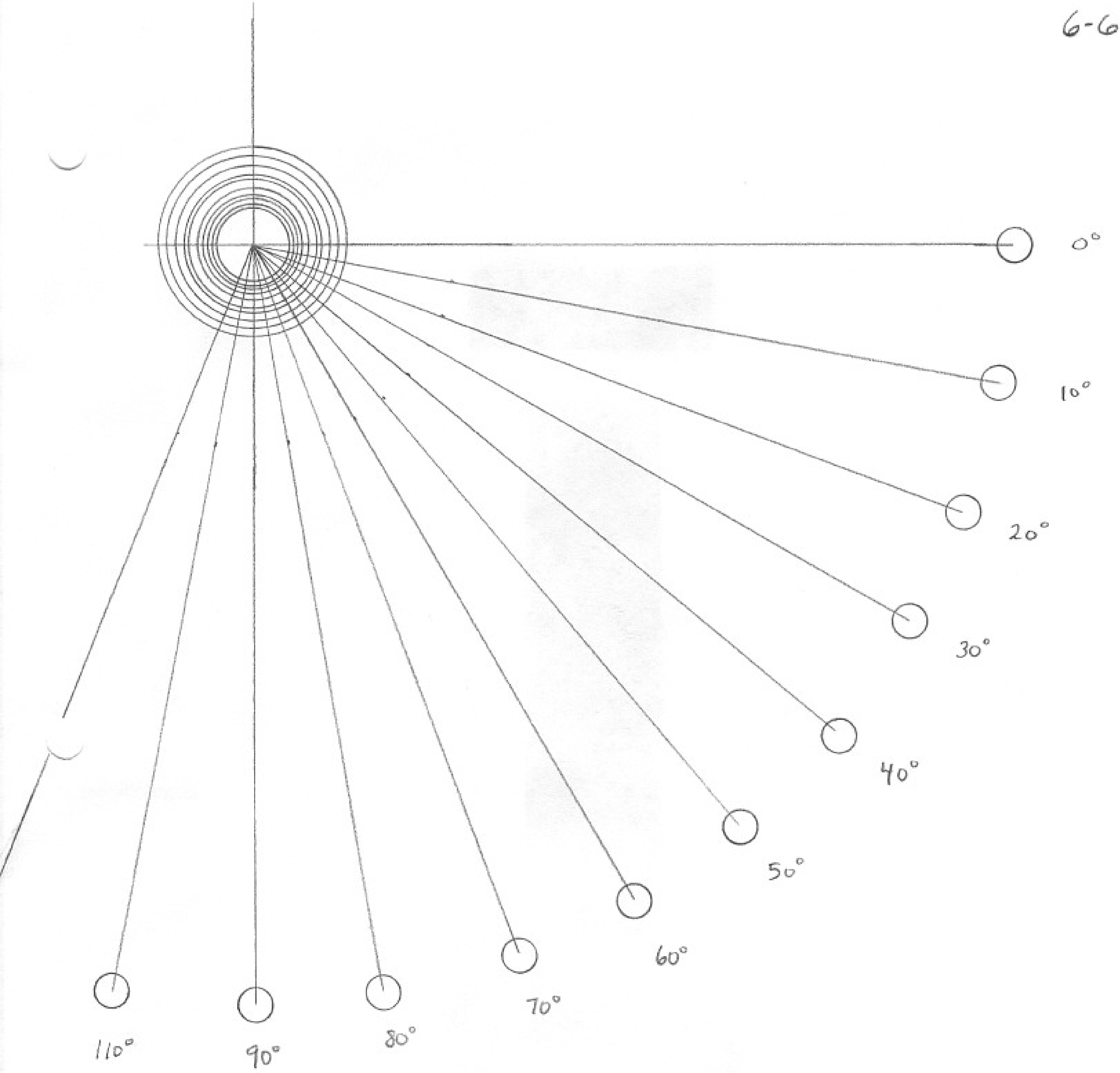
We can design the cam to make P constant, so if the user torque increases (due to strength) for a given angle, R must also increase since P is constant.

Angle (deg.)	Normalized Strength	R=R_b(strength/minimum strength)
0	.5	3"(.5/.5) = 3.0"
10	.55	3(.55/.5) = 3.3"
20	.6	3.6"
30	.7	4.2"
40	.8	4.8"
50	.85	5.1"
60	.9	5.4"
70	.95	5.7'
80	1	6.0"
90	.95	5.7"
100	.9	5.4"
110	.8	4.8"
120	.7	4.2"
130	.6	3.6"
140	.5	3.0"

constant = P

$P = \frac{\text{User Torque}}{R}$

R_b = Base Circle (3")



Note: The design variables are the base circle and the distance between the cam and the idler sprocket
The sketch above is not drawn to scale!