20-R-AM-JH-006

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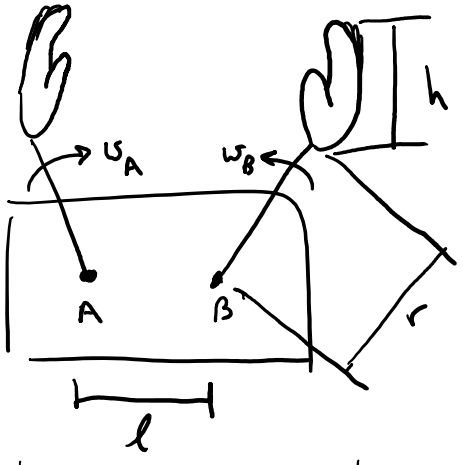
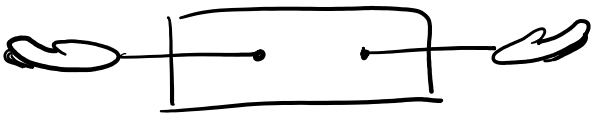
3) An automated high-fiving machine must be designed to produce a maximal impact between its two hands while avoiding material failure. The hands are designed so they are perfectly upright when they meet, and impact may be modeled at their centerpoint. If the chosen hand material can resist impacts up to 30m/s, what maximum acceleration may be specified at points A and B? Assume both sides are identical and that the hands begin at rest as shown below.

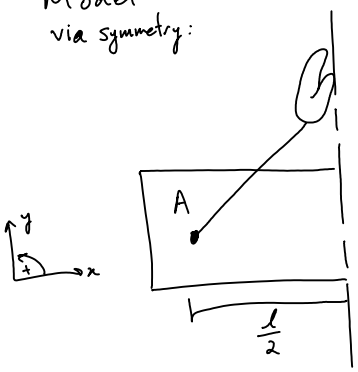
   Known parameters are as follows:
   h = 15cm
   r = 25cm
   l = 0.4m



At rest:

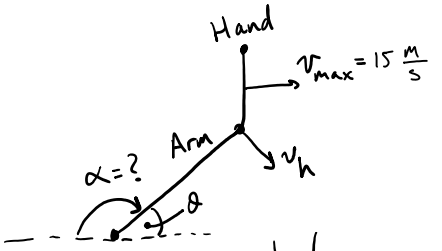


Model via symmetry:



Parameters:

$h = 0.15m$
$r = 0.25m$
$l = 0.4m$
$\vec{\omega}_0 = 0 \frac{rad}{s}$
$\vec{\omega}_f = ?$
$\theta_0 = 0$
$\theta_f = ?$
$\vec{\alpha} = ?$



v_{max} = horizontal component of v_h

To calc. α, must know behaviour of ω.

$$\vec{v}_h = \vec{\omega}_f \times \vec{r}$$

$$\vec{v}_{max} = \vec{v}_h \cos\theta$$

$$\therefore \quad \frac{\vec{v}_{max}}{\cos\theta} = \vec{\omega}_f \times \vec{r}$$

θ from geometry:

$$\theta = \cos^{-1}\left(\frac{\frac{\ell}{2}}{r}\right) = 0.64 \text{ rads}$$

$$\frac{15}{\cos(0.64\,\text{rad})}(\hat{i}) = \vec{\omega}_f \times \vec{r}$$

$$18.7\hat{i} = \begin{vmatrix} i & j & k \\ \omega_{f_1} & \omega_{f_2} & \omega_{f_3} \\ r\cos\theta & r\sin\theta & 0 \end{vmatrix}$$

$$18.7\hat{i} = (0 - \omega_{f_3} r\sin\theta)\hat{i} - (0 - \omega_{f_3} r\cos\theta)\hat{j} + (\omega_{f_1} r\sin\theta - \omega_{f_2} r\cos\theta)\hat{k}$$

$$\vec{\omega}_f = \frac{-18.7}{r\sin\theta}(\hat{k}) = -125.25\,\frac{\text{rad}}{\text{s}}\,(\hat{k})$$

$$\omega_f^2 = \omega_0^2 + 2\alpha(\theta_f - \theta_0)$$

$$\alpha = \frac{\omega_f^2 - \omega_0^2}{2(\theta_f - \theta_0)} = \frac{(-125.25)^2 - 0^2}{2((\pi - 0.64) - 0)}$$

$$\alpha_{max} = 3135.5\,\frac{\text{rad}}{\text{s}^2} \text{ (in either direction)}$$

20-R-AM-JH-007-8

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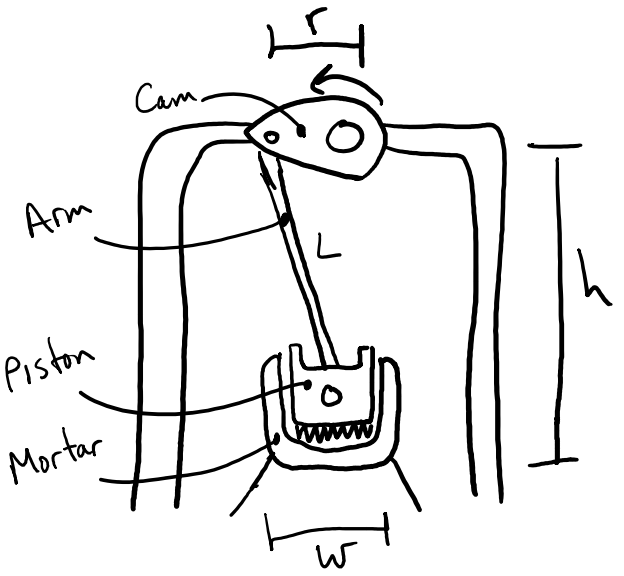
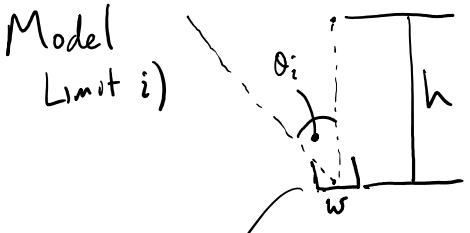
20-R-AM-JH-007)
An industrial-sized square mortar and pestle acts through a cam mechanism as shown. The cam height is set to 2m from the inner mortar surface; pestle is 30cm tall with pinned joint at the center of the cross section below. Arm L is 2.5m long. The inner mortar dimensions are 0.6m width by 1m deep.

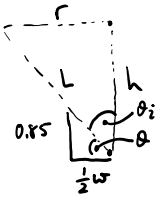
If the goal is to maximize crushing capacity (maximizing volume at the mortar before the bottom of the piston leaves the mortar walls) what value should be specified for r?

20-R-AM-JH-008)
Assume an r value of 0.8m. What is the highest velocity experienced by the center of arm L?



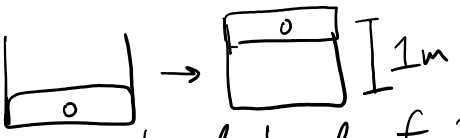
a) 2 constraints to consider:
i) Limit of r by h & w
ii) Limit of r by crush capacity





$\theta = \tan^{-1}\left(\frac{0.85}{\frac{w}{2}}\right)$
$= 1.23$ rads
$\theta_i = \frac{\pi}{2} - \theta = 0.34$ rads
$\therefore r_i = L \sin\theta_i = 2.5(\sin 0.34) = 0.83\text{m}$

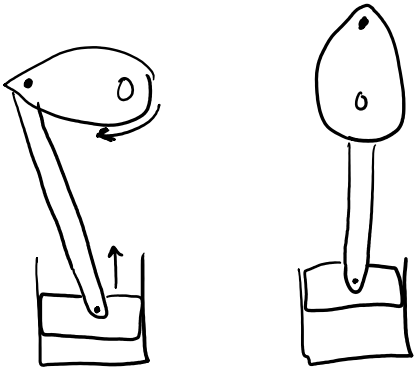
Limit ii)



max vertical travel of $1m = r_{ii}$

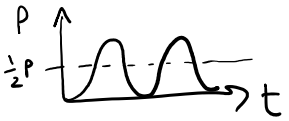
$ii > i$ ∴ Choose $r_i = 0.83m$

b) $r = 0.8m$



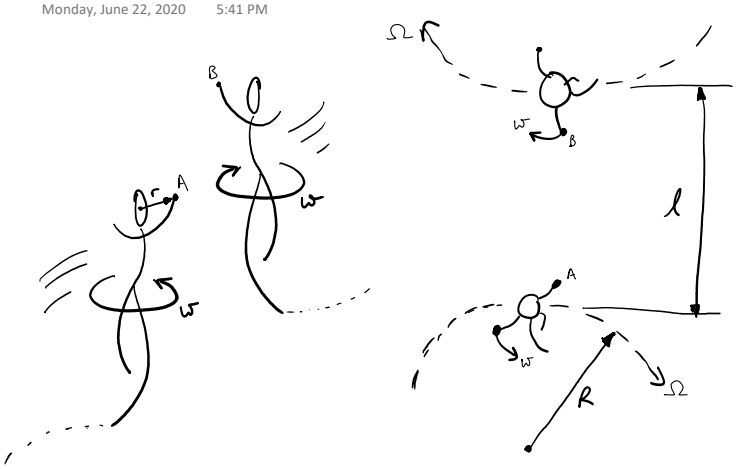
Model:

Pestle v_{max} at half of full stroke



20-R-AM-JH-009

Monday, June 22, 2020 5:41 PM

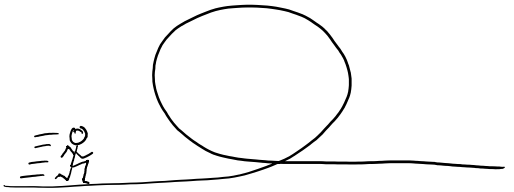


$R = 10\,m$ $\quad \Omega = 3\,\frac{rad}{s}$ $\quad l = 2\,m$

$r = 0.5\,m$ $\quad \omega = 10\,\frac{rad}{s}$

$V_{B/A} = ?$

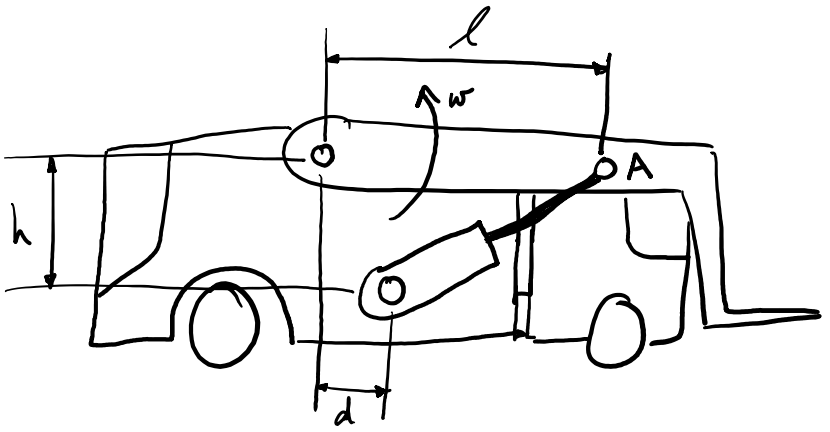
A confident sprinter believes they can run through a perfectly circular vertical loop. The sprinter weighs 70kg with a center of gravity 80cm above the ground and can maintain a constant pace of 30km/hr in all conditions. As a feasibility check, what radius should be chosen for the loop to ensure the sprinter doesn't fall off at any point? Assume a static friction of 0.9 between the track and the runner's shoes.



20-R-AM-JH-010

Monday, June 22, 2020 5:41 PM

A garbage truck must lift bins above its own cabin/roof before dropping contents into the rear container. For safety, the maximum velocity of the bin is 1m/s. If the linear actuator extends at a constant linear velocity of 0.5m/s, where must joint A be placed to ensure the bin never exceeds 1m/s total velocity?



20-R-AM-JH-011

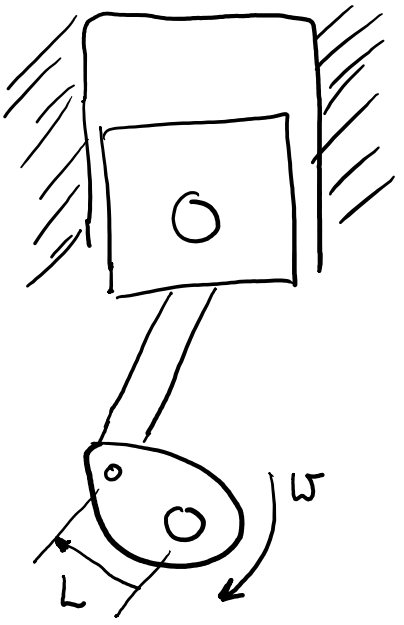
Monday, June 22, 2020 5:42 PM

A cam is rotated to produce repeating compression of a spring. The spring and cam are only in contact due to the spring force with no other fastening mechanisms. If the cam rotates at 6rad/s and the spring has four full coils, what is the velocity of any given point on the spring? Assume negligible growth or contraction of the spring, and that it only moves in compression or tension (i.e. vertically).

20-R-AM-JH-012

Monday, June 22, 2020 5:42 PM

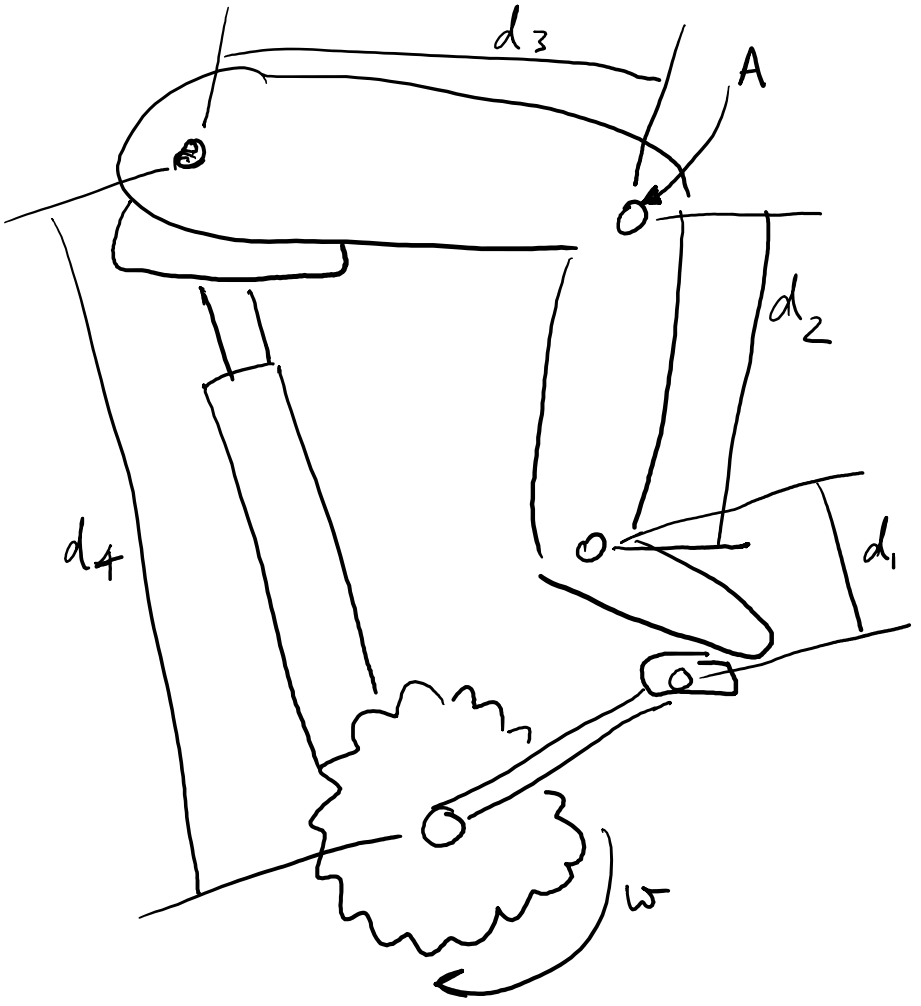
A cam drives a cylindrical piston within a rigid enclosure. If the maximum piston velocity must be kept at or below 25m/s with the cam spinning at 500 rad/s, what cam lobe length L must be specified?



20-R-AM-JH-013

Monday, June 22, 2020 5:42 PM

The human leg produces rotational motion at the crank arms of a bicycle through three major joints -- the hip, knee, and ankle. If the crank arm is rotating at 9 rad/s, what velocity is felt at the knee joint? Assume the hip joint is stationary with respect to the crank axis and that the distance between ankle and pedal axes remain constant.

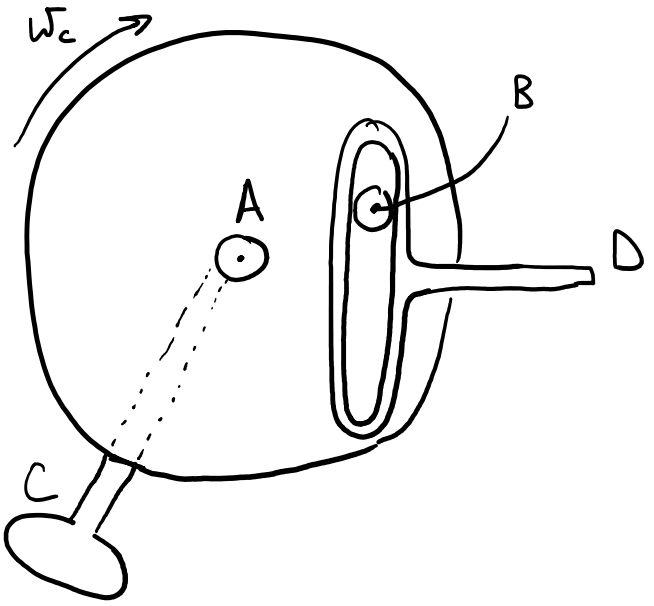


20-R-AM-JH-014

Monday, June 22, 2020 5:43 PM

A fishing reel produces linear alternating motion from rotation of the main gear A. The pinion B pushes or pulls the reel arm. A handle with crank arm C is rotated by the operator at 2rad/s.

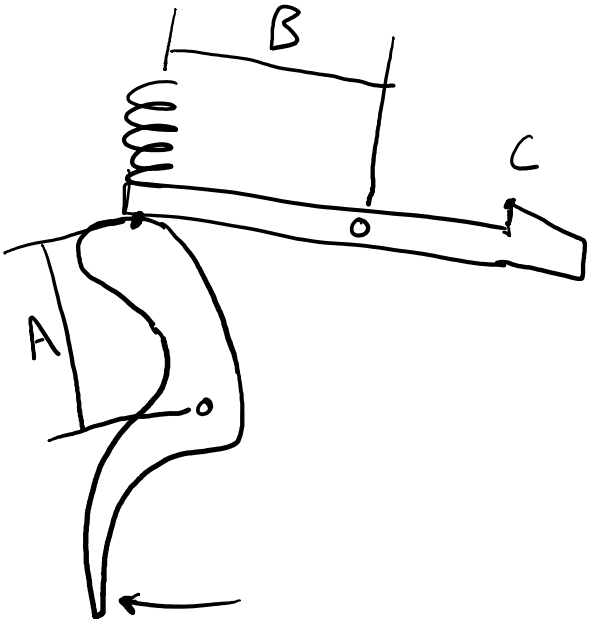
a) What distance would you specify between A and B to produce 8cm of linear travel at the reel arm from its leftmost to rightmost point?
b) What is the maximum velocity generated at the reel arm from the operator input?



20-R-AM-JH-015

Monday, June 22, 2020 5:43 PM

A trigger mechanism operates via two rigid bodies and a spring. The goal is to generate 1 degree of rotation at the release point C for every 3 degrees of motion at the trigger. What lengths A and B must be specified? Assume the distance between the contact point and pin remain constant.



20-R-AM-JH-016

Monday, June 22, 2020 5:41 PM

A garbage truck must lift bins above its own cabin/roof before dropping contents into the rear container. If the truck is driving forward at 36 km/hr while the piston lowers at 1m/s, what is the velocity of joint A with respect to the ground?