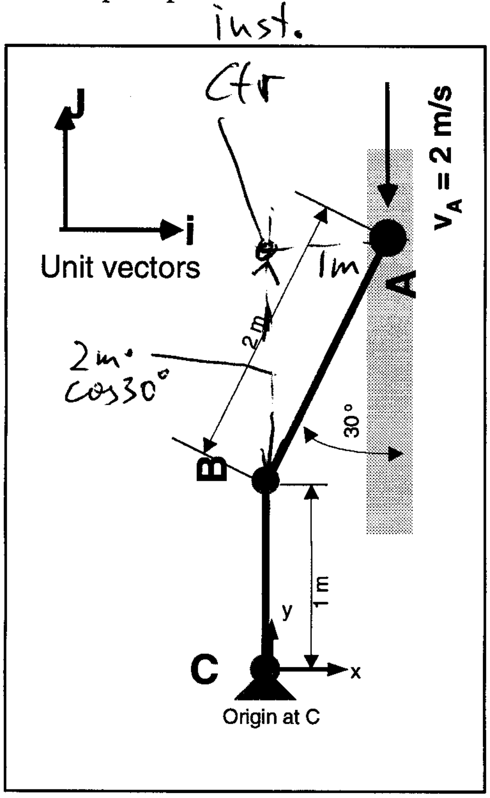
Name: KEY
Last First

UNLV, DEPARTMENT OF MECHANICAL ENGINEERING
MEG 207, SPRING 2002, Second TEST

Closed Book, one page of handwritten notes allowed. Enter the answer for each question into the space provided. Enter SI units in **all** answer spaces with brackets ( ).



1. (20 points) Point A of linkage ABC moves downward vertically with constant velocity $v_A = 2$ m/s. AB is coupled to rod BC, which is fixed at C. Determine, for AB at angle $\Theta = 30°$ as shown:

(a) the angular velocity of rod AB.

(b) the velocity vector of point B of the linkage (i- and j-components)

(c) the coordinates of the instantaneous center of the rod AB at the angle $\Theta = 30°$. Mark the instantaneous center location in the figure at left. All coordinate units are in meters. Use unit vectors i and j, and frame origin at C.

(a) inst. Ctr. at $(0 i;\ 1+2\cdot\cos 30°\ j)$

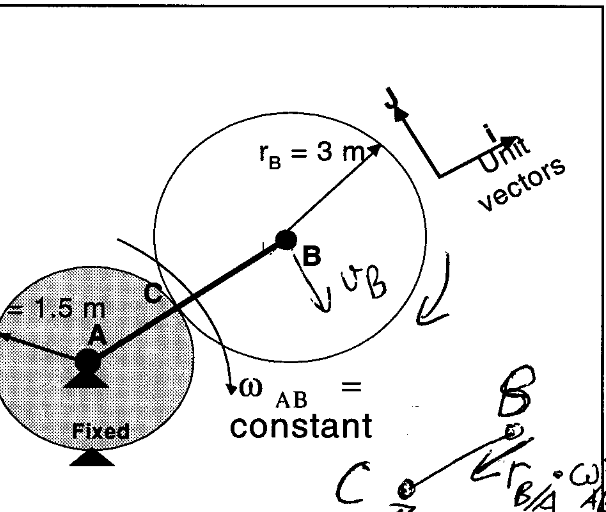
$\vec{v}_A = \vec{\omega}_{AB} \times \vec{r}_{A/Ctr}$

or $-2\,m/s = 1m \cdot \omega_{AB} \Rightarrow \omega_{AB} = -2$

(b) $\vec{v}_B = \vec{\omega}_{AB} \times \vec{r}_{B/Ctr}$

$v_B = -2 \frac{rad}{s} \cdot 1.732\,m = -3.464\, i\ \frac{m}{s}$

Answer ω_{AB} =	$-2\,k$	(rad/s Units)
v_B =	$-3.464\, i$	(m/s Units)
Inst. CTR at :	$0 \cdot i + 1 + 2\cdot\cos 30°\, j$ m	x- and y components, enter Units)



gure 2 Gears

2. (20 Points) Arm AB rotates with a constant angular velocity of 10 rad/s clockwise. Gear A does not rotate. Determine

(a) the angular velocity of gear B

(b) the acceleration of gear B at its contact point, C, with fixed gear A in terms of the i-and j-coordinates shown at left..

(a) C is inst. center. $v_B = 4.5m \cdot 10 \frac{rad}{s} = 3m \cdot \omega_b$

$\omega_b = \frac{45}{3} = -15 \frac{rad}{s} k$ (clockwise)

(b) $\vec{a}_C = \vec{a}_B + \vec{a}_{C/B}$ $\quad \omega_B = const \rightarrow \alpha_B = 0$

only centripetal accelerations exist:

$\vec{a}_B = -4.5m \cdot 10^2 \left(\frac{rad}{s}\right)^2 i$; $\vec{a}_{C/B} = +3m \cdot 15^2 \left(\frac{rad}{s}\right)^2 \cdot i$

$a_C = 675 - 450 = 225 \frac{m}{s^2} \cdot i$

Answer	$\omega_B = -15k$	(rad/s Units)
	$a_C = +225\, i$	(rad/s Units)

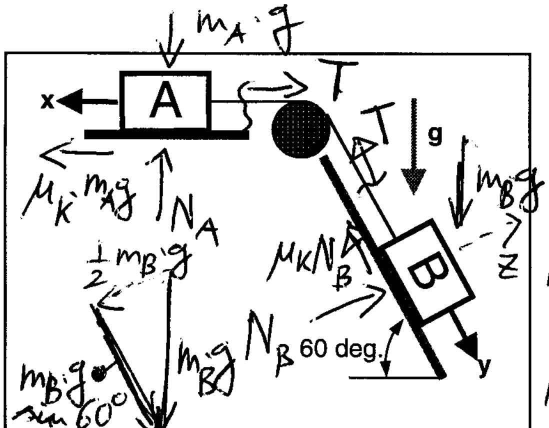


Figure 3 Two Masses

3. (30 points) Masses A (3 kg) and B (2 kg) are released from rest as shown. Friction coeff.: $\mu_k = 0.1$ The rope length is constant. Using x- and y-coordinates at left, determine

(a) the acceleration of mass B.

(b) the velocity of block B after B has moved 2 meters in y-direction.

Mass A: $\Sigma F_x = -T + \mu_K m_A g = m_A \cdot \ddot{x} = -m_A \ddot{y}$ (1)

$\ddot{y} = -\ddot{x}$

Mass B: $\Sigma F_y = -T + m_B g \sin 60° - \mu_K N_B = m_B \cdot \ddot{y}$ (2)

$\Sigma F_z: N_B = m_B g \cos 60° = \frac{1}{2} m_B g$ (3)

Solving (1) for T and substituting T in (2) gives: $-\mu_K m_A g - \mu_K \frac{1}{2} m_B g + m_B g \sin 60° = (m_A + m_B)\ddot{y}$

thus $\ddot{y} = a_B = g[(m_B \sin 60°) - 0.1(m_A + m_B/2)]/(m_A + m_B) = 9.81(1.732 - 0.4)/5$

(b) $\frac{1}{2} v_B^2 = a_B(x - \cancel{x_0}^{0}) \rightarrow v_B^2 = 2 \cdot 2.61 \cdot 2 \frac{m^2}{s^2}$

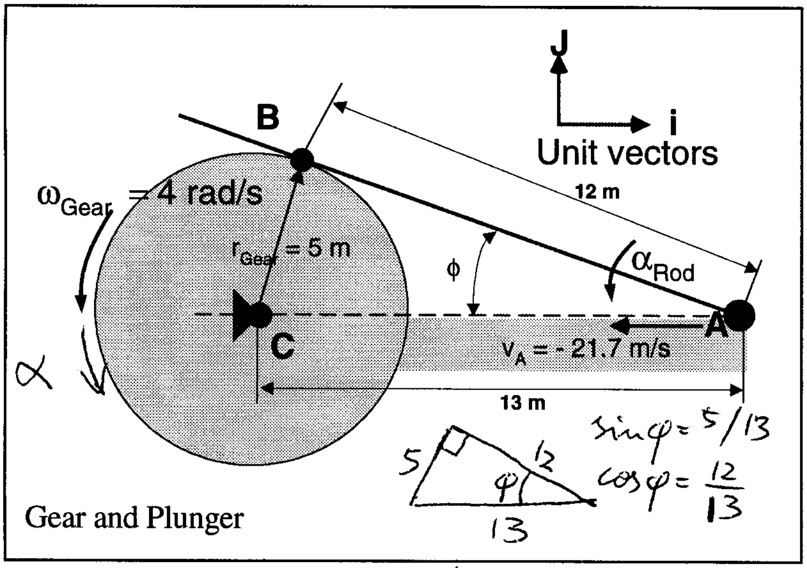
Answer

a_B	$= \ddot{y} = 2.61$	(m/s^2)
V_B(2m) =	3.23	(m/s)

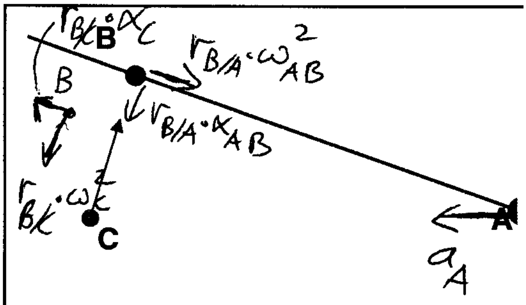
4. (30 points) At the instant shown the end A of plunger AB has a velocity of 21.7 m/s to the left, and the angular velocity of plunger AB is ω_{AB} = -0.694 rad/s (counterclockwise). The plunger speed at A is DECREASING at a rate of 0.25 m/s^2.

(a) Write the **vector** equation for the acceleration of contact point B, and graph schematically the acceleration at B as seen from points A and C, respectively. Clearly label each vector in the drawing with its corresponding expression in the vector equation (e.g. $r*\omega^2$ etc).

(b) Determine the angular accelerations α_{AB} of the rod AB and α_{Gear} at this instant.



Gear and Plunger



Answer (a) Graph Vectors above. Enter vector equation below:

$\vec{a}_B = \vec{\alpha}_C \times \vec{r}_{B/C} + \vec{\omega}(\vec{\omega} \times \vec{r}_{B/C}) = \vec{a}_A + \vec{\alpha}_{AB} \times \vec{r}_{B/A} + \vec{\omega}_{AB} \times (\vec{\omega}_{AB} \times \vec{r}_{B/A})$

(b) $\vec{a}_B = r\alpha + r\omega_C^2 = -0.25i + r_{B/A}\cdot\alpha_{AB} + r_{B/A}\cdot\omega_{AB}^2$

using $\sin\varphi = 5/13$ and $\cos\varphi = 12/13$ we get:

$$5\cdot\alpha\left(-\frac{12}{13}i + \frac{5}{13}j\right) + 5\cdot 4^2\cdot\left(-\frac{5}{13}i - \frac{12}{13}j\right) = -0.25i + 12\cdot\alpha_{AB}\left(-\frac{5}{13}\cdot i - \frac{12}{13}j\right) + 12\cdot(0.694^2)\left(\frac{12}{13}i - \frac{5}{13}j\right)$$

We have 2 equations for the unknown variables α and α_{AB}:

i: $-60\alpha_{Gear} - 400 = -3.25 - 60\alpha_{AB} + 69.3$

j: $25\alpha_{Gear} - 960 = -144\alpha_{AB} - 28.9$

Simplifying:

$\alpha_{AB} - \alpha_{Gear} = 7.76$

$5.76\alpha_{AB} + \alpha_{Gear} = 37.24$

(If you assumed a_A as 0.25 m/s^2 to the right, alpha values are -1.7 and -6.17.)

Answer (b) α_{AB} =	+6.19	(rad/s^2)	C.W.
α_{Gear} =	-1.567	(rad/s^2)	C.C.W.