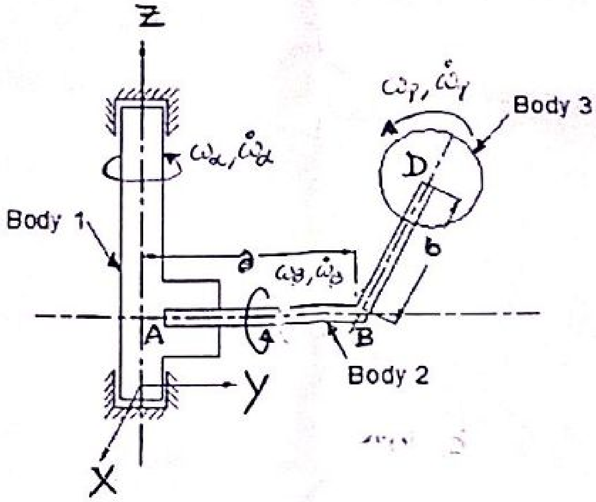
Engineering Mechanics (APL 100) Minor II

8:00-9:00 AM, March 19th, 2015 **Total Time: 60 minutes** **Maximum Points: 100**

1. Consider the mechanism of three rigid bodies shown. X-Y-Z are axes fixed to the ground reference frame. Body 1 rotates with respect to ground at the rates ω_α and $\dot{\omega}_\alpha$. Body 2 (bent rod) rotates at the rates ω_β and $\dot{\omega}_\beta$, with respect to body 1. Body 3 (disc) spins at the rates ω_γ and $\dot{\omega}_\gamma$, with respect to body 2. Find the angular velocities and angular accelerations of all three bodies with respect to the ground. **(15 points)**



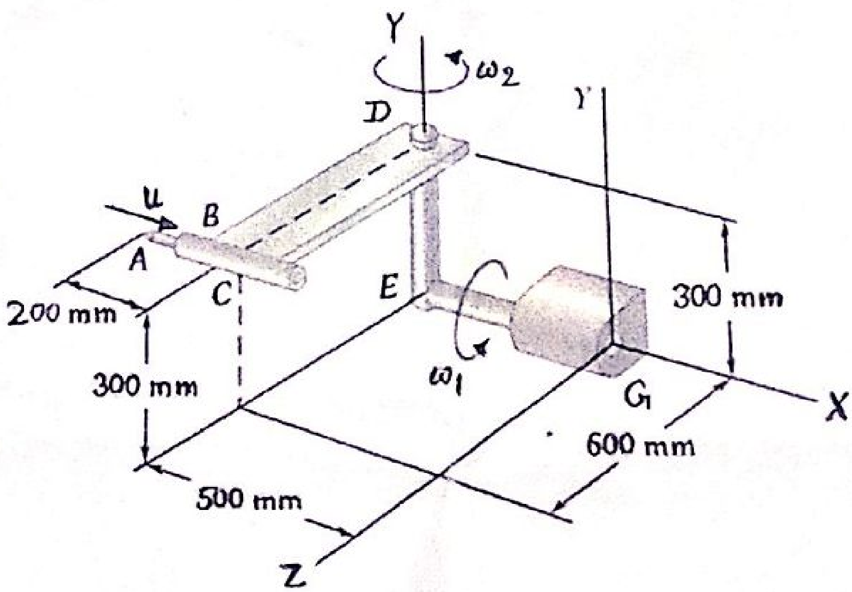
Length (AB) = a

ABD is in the Y-Z plane at this instant

$\angle ABD = 120°$

Length (BD) = b.

2. The position of the stylus tip A is controlled by the robot shown. In the position shown the stylus moves at a speed $u = (3t + 5)$ m/s relative to the solenoid BC. At the same time, arm CD rotates at the constant rate ω_2 = 4rad/s with respect to component DEG. Knowing that the entire robot rotates about the X axis at the constant rate ω_1 = 2rad/s, determine the expressions for (a) the velocity of A, (b) the acceleration of A at the time instant $t = 0$ (as shown in the figure). **(35 points)**



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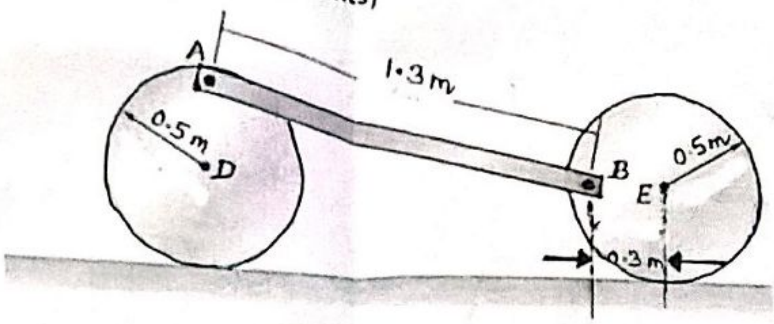
3. Two wheels each with radius 0.5 m roll without slipping on the horizontal surface. Knowing that Point D has a velocity of $V_D = 1.5$ m/s and acceleration of $a_D = 12$ m/s² to the right, determine the angular velocity and angular acceleration of the right wheel at the given instant. At this instant, AD is perpendicular to the ground and DB is parallel to the ground. **(50 Points)**



BE = 0·3 m
AD = 0·5 m

Useful formulae : [May all be used directly without derivation]

① $\dot{\vec{A}}_{/F} = \dot{\vec{A}}_{/m} + \vec{\omega}_{m/F} \times \vec{A}$

② $\vec{V}_{P/F} = \vec{V}_{A/F} + \vec{\omega}_{m/F} \times \vec{r}_{PA} + \vec{V}_{P/m}$

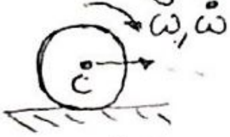
③ $\vec{a}_{P/F} = \vec{a}_{A/F} + \dot{\vec{\omega}}_{m/F} \times \vec{r}_{PA} + \vec{\omega}_{m/F} \times (\vec{\omega}_{m/F} \times \vec{r}_{PA}) + 2\vec{\omega}_{m/F} \times \vec{V}_{P/m} + \vec{a}_{P/m}$

NOTE: $\vec{r}_{PA} \equiv \vec{AP}$

④ $\vec{\omega}_{3/1} = \vec{\omega}_{3/2} + \vec{\omega}_{2/1}$

⑤ $\dot{\vec{\omega}}_{3/1} = \dot{\vec{\omega}}_{3/2} + \dot{\vec{\omega}}_{2/1} + \vec{\omega}_{2/1} \times \vec{\omega}_{3/2}$

⑥ For a cylinder rolling on ground without slipping,



$\vec{V}_c = \omega R \ (\rightarrow)$

$\vec{a}_c = \dot{\omega} R \ (\rightarrow)$

ω: angular velocity

$\dot{\omega}$: angular acceleration

C: Center of Cylinder