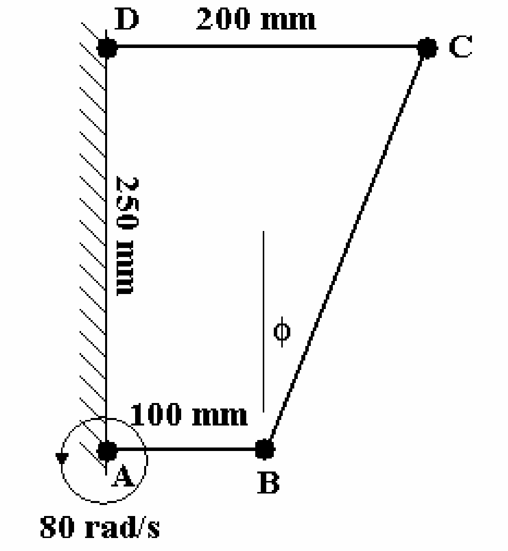
<u>DYNAMICS OF MECHANICAL SYSTEMS D225 Q 5 2004</u>

The diagrams shows a "4-Bar Mechanism" used to shake a conveyor for sorting minerals in various mining operations. Points A and D are fixed in space. Link AB is 100 mm long and this link is caused to rotate at a constant angular velocity, ω = 80 rad/s. Link BC is a connector link. Link CD is 200 mm long and this link moves in response to the motion of AB but this link does not undergo complete revolutions. At one instant in time, links AB and BC are both horizontal.



(a) Calculate the angular velocities of links BC and CD at this instant.

(b) Calculate the angular accelerations of links BC and CD at this instant.

(c) Point masses of 10 kg are present at joints B and C. Ignore the masses of links (AB, BC, CD}. The mechanism operates in a vertical plane and gravity acts vertically downward on joints B and C. Compute the torque necessary at point A at this instant to maintain the constant rotational angular velocity of AB.

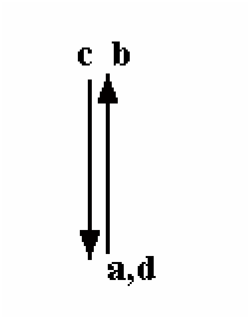
SOLUTION

(a) First calculate the angle ϕ $\phi = \tan^{-1}(100/250) = 21.8^{o}$

Also calculate the length of BC BC = $\sqrt{(100^2 + 250^2)}$ = 269.26 mm

Next calculate the tangential velocity of B relative to A $(v_B)_C = \omega R$ = 80 x 0.1 = 8 m/s

Next draw the velocity diagram. Note a and d are coincident points as they are joined by a rigid link. Also note that since the tangential velocity of C relative to D $(v_C)_D$ is vertical and must end at d, then the tangential velocity of C relative to B $(v_C)_B$ must be zero so the diagram is as shown and $(v_C)_D = (v_B)_C$ = 8 m/s



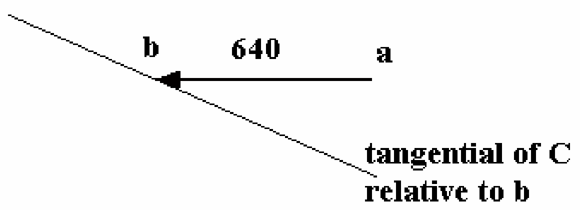
The angular velocity of link CD = 8/radius = 8/0.2 = 40 rad/s.
The angular velocity of link BC is zero.

(b) First calculate the radial acceleration of B relative to A

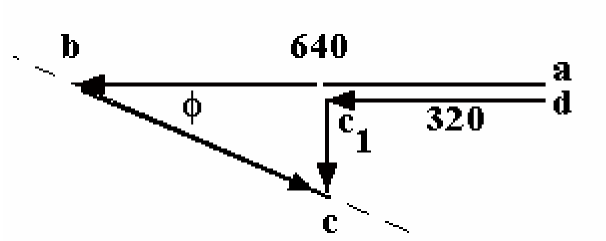
$(a_B)_A = \omega^2$ x radius = 80^2 x 0.1 = 640 m/s^2 The direction is towards A

The tangential acceleration of B is zero since the link rotates at constant velocity.

The radial acceleration of C relative to B is zero since it has no angular velocity. The tangential velocity is unknown but lies in a direction normal to the link.



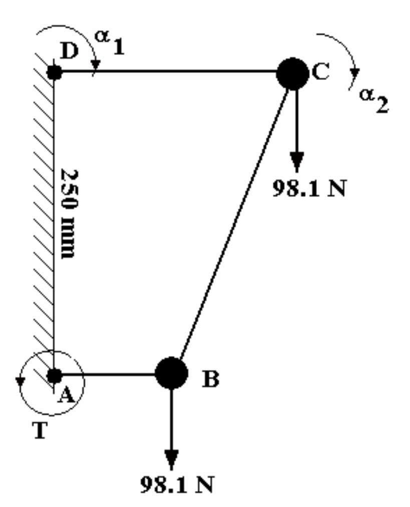
The radial acceleration of C relative to D is $(a_C)_D = \omega^2$ x radius = 40^2 x 0.2 = 320 m/s^2 The direction is towards D. The tangential acceleration is unknown but normal to link DC so the acceleration diagram may be completed.



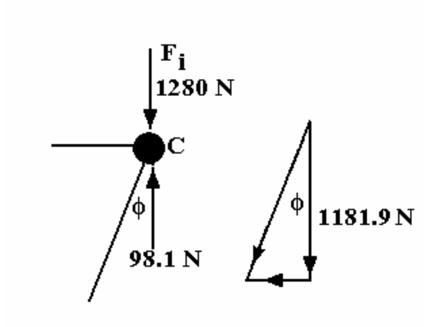
The tangential acceleration of C to D can be scaled or calculated.
Tangential acceleration of CD is 320 tan ϕ = 128 m/s^2.
The angular acceleration of CD is 128/radius α_1= 128/0.2 = 640 rad/s^2.

The tangential acceleration of C to B can be scaled or calculated.
Tangential acceleration of C to B is 128/sin ϕ = 344.65 m/s^2.
The angular acceleration of BC is 344.65/radius α_2= 344.65/0.269 = 1.28 rad/s^2.

(c) We need to sketch the forces present in the system. There are two weights (10 g) of 98.1 N acting down at B and C.



Examine the forces acting on C. Mass C is accelerating down at 128 m/s^2 so F_i = m a = 10 x 128 = 1280 N



Link BC must supply an upwards force of 98.1 N to support the weight but pull down with a force F_i to accelerate the mass so the total vertical force required is 1280 – 98.1=1181.9 N. It acts in a downwards direction.
There is no point resolving this force since the vertical component must be transmitted to point B and the horizontal component produces no torque at A.
There is no force to overcome the inertia of the mass at B since it is not accelerating so the total vertical force required at point B must be 1181.9 N down less the weight.

F = 1181.9 - 98.1 = 1083.8 N

The torque T at A is 1083.8 x 0.1 = 108.38 N m and it must be in a clockwise direction.