Dependent Motion

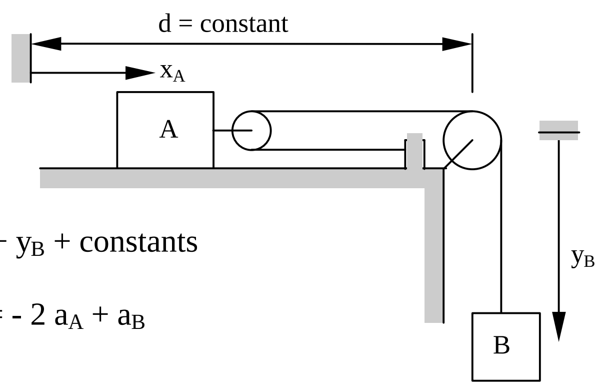
Sometimes the motion of two or more objects are related because of a constraint. To relate the motion of the objects a constraint equation needs to be determined. A common example of dependent motion is when objects are connected by an inextensible cable.

The following procedure can be very helpful when approaching problems of this type:

1. Set up a datum for each position vector and draw the position vectors
2. Determine a constraint equation such as the length of cable connecting the objects.
3. Differentiate the constraint equation to determine velocity and acceleration constraint equations.

Example 1

Known: Two objects are connected by a cable
Find: Determine a relationship between the acceleration of the two objects
Given: See picture
Analysis:
Strategy: Determine a constraint equation



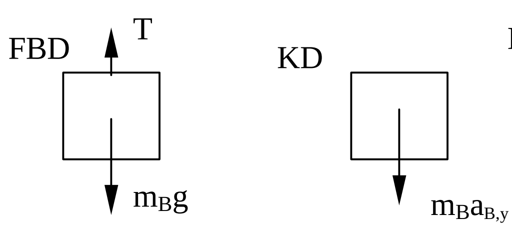
Step 1: Define datums and position vectors as shown.

Step 2: Write constraint equation: $L = 2(d-x_A) + y_B + \text{constants}$

Step 3: Differentiate: $0 = -2v_A + v_B$ and $0 = -2a_A + a_B$

Comments:

1) Note that in these equations the positive direction for a_A and a_B are to the right and down respectively. This is important if a constraint equation is used in conjunction with conservation of linear momentum. For example if we applied conservation of linear momentum to block B we would get:



Linear momentum in the y-direction

$$^{+}\!\downarrow \Sigma F_y = ma_y$$

$$m_Bg - T = m_Ba_{B,y}$$

If, in the linear momentum equation, up had been defined to be positive then the equation obtained would be inconsistent with the constraint relationship derived.

2) This problem probably could have been done by inspection by counting the number of cables associated with each block and then by reasoning out the kinematic relationship.