Modelling and control summaries

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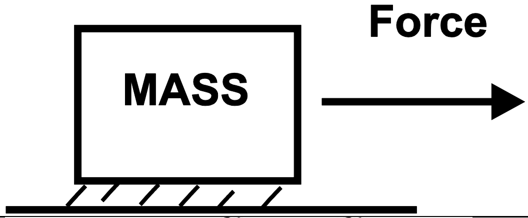
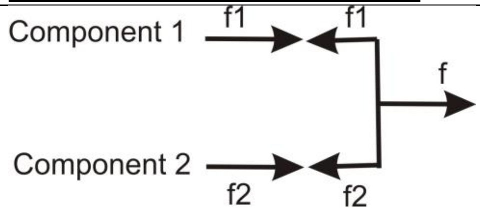
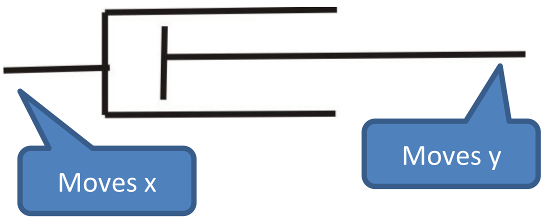
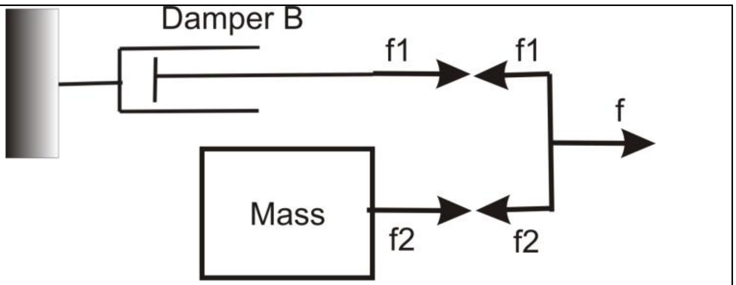
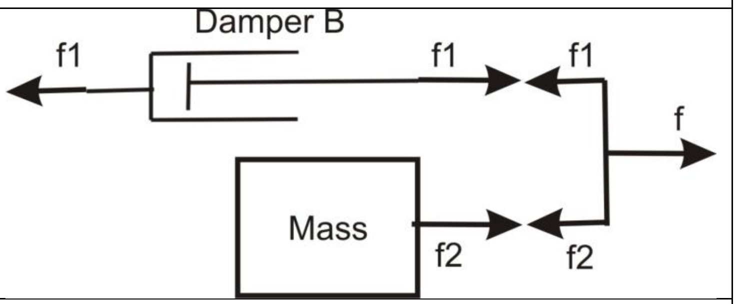
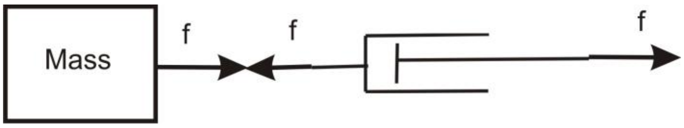
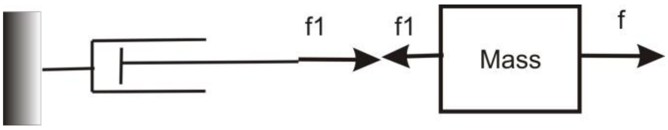
1st order modelling 1: mass-damper

This summary assumes students are familiar with the basic modelling of springs and dampers, Newton's laws, concepts of force balance and also continuity (points joined together move the same distance).

Simple example of a mass damper is a mass on which a force is causing acceleration but friction acts to slow down the velocity – this may represent a simple car model where the engine provides the force 'f' and the friction (or drag) depends upon the speed.	
FORCE BALANCE: The normal way to model these scenarios is to consider the force as being made up of different (parallel) components, here f1 and f2. • f1 represents the friction force/drag. This is assumed to be proportional to speed! • f2 represents the force required to accelerate the mass. Some of the engine force is needed to overcome drag, what is remaining is used for acceleration:	 $f1 = Bv; \quad f2 = M\frac{dv}{dt}$
Combining the individual forces with f=f1+f2 gives:	$f = Bv + M\frac{dv}{dt}$
The simple model for a mass-damper system is a **1st order ODE** with parameters the friction coefficient B and the mass M.	

REMARKS: Readers will need to take some care with real mechanical systems because friction can take many different forms and this impacts on how it enters the model equation.

Within a suspension unit, a damper is the friction component. This may allow that both ends move or just one end moves. Friction force depends on the relative speed of each end! $f = B(\frac{dy}{dt} - \frac{dx}{dt})$	
In school level physics, static friction was considered to dominant over dynamic friction and thus friction was considered dependent on the normal force between an object and a surface and thus **A CONSTANT!** **This scenario is much less common with more complicated models.**	

In the earlier notes on modelling, readers will also have noted that the modelling depends on whether components are arranged in parallel or series. This figure is in effect, a parallel arrangement so that the force applied is distributed between the components.	
This arrangement looks similar but beware as the extension of the damper is no longer assumed to match the movement of the mass as both ends are free! More information is needed to model this.	
In a series arrangement, the same force that is going through the damper, also applies to the mass, but the extension of the damper and movement of the mass need not match although the movements must match at the point where connected.	
In this arrangement, one end of the damper is fixed and thus does not move. Also, this is NOT a series arrangement even though it may appear so because: • The same force is not applied through each component, rather the force is shared. • Each component has the same displacement. Hence, this is equivalent to a parallel arrangement.	 $f1 = Bv; \quad f - f1 = M\frac{dv}{dt}$