MODAL SPACE - IN OUR OWN LITTLE WORLD

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Do we really need an accurate updated model? What are the effects if it is not perfect?
I have some very good examples to illustrate this.

Model updating is an important step in the development of an accurate system model. If any of the components of the system are not modeled correctly, then the overall system characteristics will not be accurate. Of course someone has to define what is acceptable and unacceptable in terms of response for the system. But that is a different item to address.

What I want to talk about here is the effect of a component frequency in relation to the system response. Components are typically much easier to model and update than the overall system. In fact, the biggest problems in developing a system model are the boundary conditions and the interaction of components in a system model. So the thing that I want to address here is the relationship of components with each other in a system model. Of course there are many ways to write all of those relationships. What I want to do here is identify the relationship from a very simple representation of the various systems. First the simple single degree of freedom tuned absorber will be considered and then the mode complicated multiple degree of freedom system will be addressed.

So the first thing that has to be discussed is the simple representation of a component in terms of its mass and stiffness, or its modal characteristics or its frequency response characteristic. Figure 1 shows a conceptualization of a finite element model of a component which is described in terms of its mass and stiffness. But in this form, it is not easy to interpret how the various modes affect the component overall. An eigensolution of the component reduces the complicated mass and stiffness into more simplistic set of single degree of freedom systems which are linearly independent and orthogonal with each other. The lower portion of Figure 1 shows the component as a set of single degree of freedom systems as well as a set of frequency responses for each of the modes of the system. So the component can be best understood if the modal characteristics are understood.

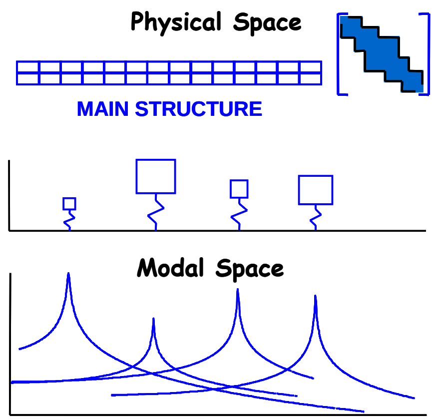

Figure 1 – Physical and Modal Representation for a Component

Now what would happen to the component if another spring-mass system were attached (but for now let's assume that it is not aligned with any frequency of the system)? Figure 2 adds that spring-mass system and the effects are very minimal on the original component modes. But what if the spring-mass system is "tuned" to a particular mode?

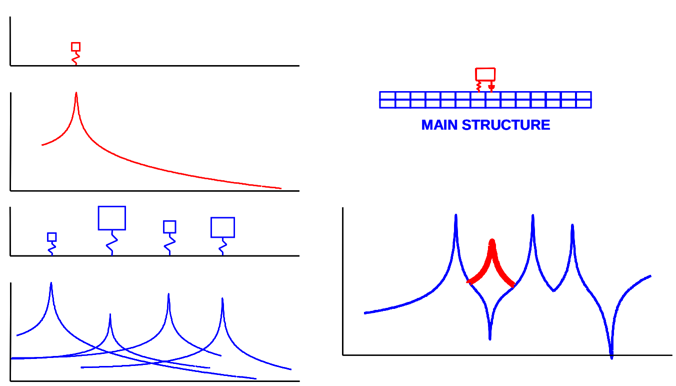

Figure 2 – Component with Untuned Spring-Mass System

Figure 3 shows the effects on the frequency response if the spring-mass system is coincident with one of the modes and Figure 4 shows the effects if two spring-mass systems are added to the component. These effects are exactly what are expected for a tuned mass-spring absorber. There is a dynamic interaction between the added spring-mass system and the component modes of the system.

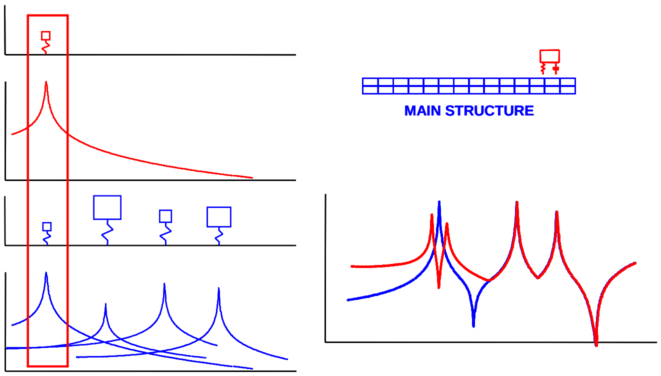

Figure 3 – Component with Tuned Spring-Mass System

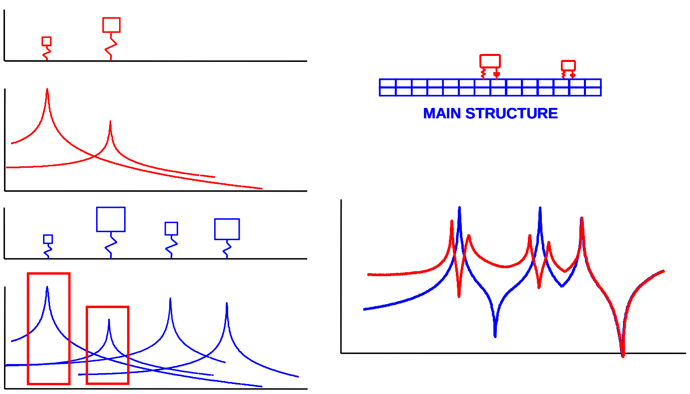

Figure 4 – Component with Two Tuned Spring-Mass Systems

So from these two schematics in Figure 3 and 4, it is very clear that if the frequencies of the spring-mass system are specifically selected to be coincident with one of the modes of the system, there will be a dramatic change in the dynamic characteristics of the component. However, if the frequencies of the spring-mass system are not selected correctly (as in Figure 2) then there will be no significant dynamic coupling between the added spring-mass system and the component.

Now that we have that concept in place, let's consider the coupling of two components to form a system model. But instead of considering the two components as mass and stiffness matrices, it is much more advantageous to consider them as either a collection of modal mass/spring systems in modal space or as a set of single degree of freedom response functions.

Figure 5 shows this representation for Component A and Component B. In order for the proper coupling of the two components to occur, the modes of each of the components must be properly specified. In Figure 5, the modes of Component A are not close to the modes in Component B, and therefore, there will not be significant coupling between the two components.

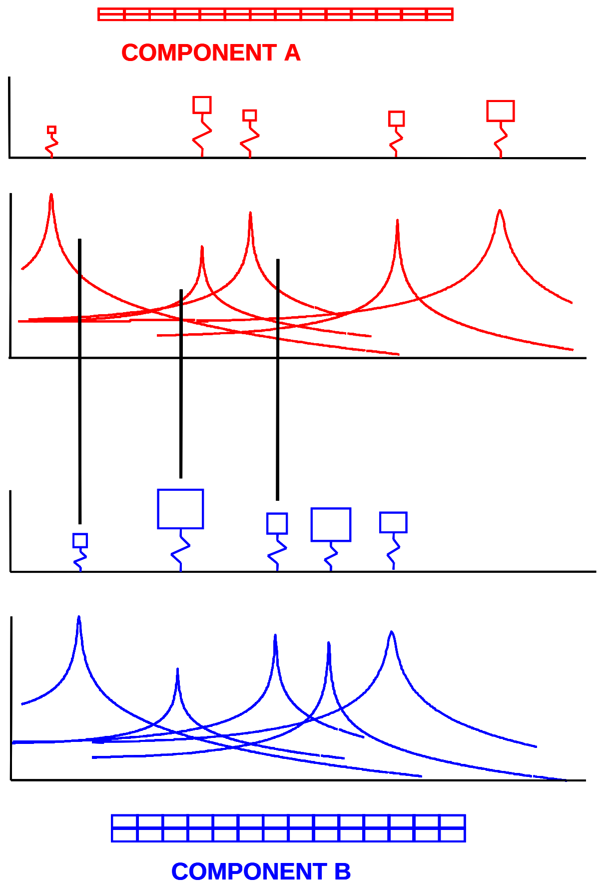

Figure 5 – Physical Coupling of Two Components

But what if the modes of either one of the components are not correct and the actual modes are much closer to each other? Then there should be a significant amount of dynamic coupling between the two components wherever the modes of both are aligned. The coupling between the two components is heavily dependent on the relative relationship of the frequencies of the two systems. Therefore, it is imperative that the modes of each component be properly identified so that the correct dynamic interaction exists in the assembled system model.

I hope that this helps to show why the modes of each component must be identified correctly. The component modes must be updated to properly identify the dynamic characteristics of the component. In just considering the mass and stiffness matrices, it is not apparent why the modes must be identified correctly. By representing the component in the modal or frequency domain, the need for updating the component models is much more obvious. If you have any more questions on modal analysis, just ask me.