24-261 Statics, Fall 2001
Laboratory #1
Due: 1:30 PM, September 13, 2001

Background

This laboratory is intended to help you develop good habits in thinking about mechanical interactions and constructing free body diagrams. A mechanical interaction is always between two bodies: for most engineering problems the bodies are in contact or one of the two bodies is the earth exerting a gravitational force. A free body diagram displays a single body along with the interactions it has with all other bodies.

It is often sufficient to represent the interaction between contacting bodies by an equal and opposite force and/or an equal and opposite moment. This force and/or moment act at particular points on each of the two interacting bodies. In addition, the force and moment that the first body exerts on the second are equal and opposite to the force and moment exerted by the second body on the first.

One goal of mechanics is to quantify the forces and moments between various bodies; this generally requires one or more analyses. However, sometimes certain aspects of the forces and moments can sometimes be determined with no analysis.

In the case of interactions between bodies in contact, the *magnitude* of the force and moment can never be known given only the two bodies. The magnitude can be determined only by considering the effects of *additional* bodies. On the other hand, the direction or sense of the force and moment can sometimes be determined given only the two bodies.

For example, say two bodies press against one another across a known common plane. Then, if we neglect the friction between the bodies (a common approximation in many engineering situations), the force must act perpendicularly to the common plane. The sense of the force is also known: the two bodies are *pushing* each other apart, rather than *pulling* on each other. The magnitude of the contact force is *not* known, however, without appealing to other bodies.

The above description presumes that the contacting bodies do not adhere (stick) to one other. If bodies adhere, then not only are the direction and sense of the force not known, but there can also be a moment exerted by the bodies on each other.

In the case of gravitational interaction between the earth and a body near the earth, the magnitude, direction and location of the force of interaction are known if the mass of the body (and the distribution of mass) are known.

Students are to consider the configurations below in a group and to discuss the questions together. Each student is to hand in a report responding to each of the tasks or questions.

Snow Shovel

Configuration 1: One student holds the shovel horizontally, with the pan facing upward. The right hand is at the remote end of the handle and the left hand supports the handle at roughly 1/3 of the way towards the pan. The shovel handle should just press against the hands. A book is placed on the pan to simulate snow. The book should be centered so that the shovel does not tilt to the side. (You might need another student to balance against tilting with a finger on the pan.)

- The student holding the shovel slides the left hand towards the right and back again. Describe in words the change in what you feel in your hands. Explain the reason for this change in layman's terms.

- Draw the shovel alone in an isometric view (you can make this drawing presentable later for handing in). Consider one particular position of your left hand.

- The goal is to draw a free body diagram of only the shovel, given that the shovel holds a book and you support the shovel as described above. The bodies that contact the shovel are your left hand, your right hand, and the book. The earth also interacts with the shovel. Consider the force and/or moment acting between the shovel and each of the contacting bodies. On a diagram of the shovel, draw the force and/or moment vector exerted by the contacting body on the shovel. Draw the vectors in the correct direction and sense relative to the isometric drawing of the shovel. Near each of the forces and/or moments write the name of each contacting body (e.g., "left hand") and draw a box around the name. Then, draw the equal and opposite force and/or moment vector exerted by the shovel on that contacting body, as if it were acting on the box containing text.

- Consider the interaction between the earth and the shovel. Draw an appropriate vector on the diagram of the shovel that represents what the earth exerts on the shovel. Explain in words how you might decide where to draw the force of the earth on the shovel. You have drawn all the interactions that should appear in the free body diagram of the shovel.

Configuration 2: Rather than using both hands, try to balance the shovel (holding the book) in a horizontal position with only your left hand. Your left hand should still grip the stick (not the pan), but you may move it closer to the pan for comfort if necessary, but it should still be more than half of the handle's length away from the pan.

- Draw a free body diagram of the shovel showing all forces and moments acting on it. Represent each contacting body by its name in a box, and draw next to that box the force and/or moment exerted by the shovel on the contacting body.

Configuration 3: Place the book not in the center of the pan, but to the right side (as you are looking from the handle toward the pan). Have the handle merely rest against your open left hand, and let the right hand hold the shovel so that the pan remains flat.

- Draw a free body diagram of the shovel showing all forces and moments acting on it. Represent each contacting body by its name in a box, and draw next to that box the force and/or moment exerted by the shovel on the contacting body.

Configuration 4: Place the book to the left side of the blade (as you are looking from the stick toward the blade). Now hold the right hand open flat over the handle, so the handle rests against it. With the left hand hold the shovel so that the blade remains flat.

- Draw a free body diagram of the shovel showing all forces and moments acting on it. Represent each contacting body by its name in a box, and draw next to that box the force and/or moment exerted by the shovel on the contacting body.

Screwdriver

Grip the screwdriver with your right hand and insert the screwdriver into the screw slot. Attempt ***very lightly*** to turn the screw clockwise (so as to tighten the screw or drive it in).

- Draw a free body diagram of only the screwdriver showing all forces and moments acting on it. (Ignore the interaction between the earth and the screwdriver.) The forces should account for the detailed way in which the screw actually contacts the screwdriver, and your drawing of the screwdriver should reflect this detail. In addition, put "right hand" in a box, and draw the force and/or moment exerted by the screwdriver on your right hand.

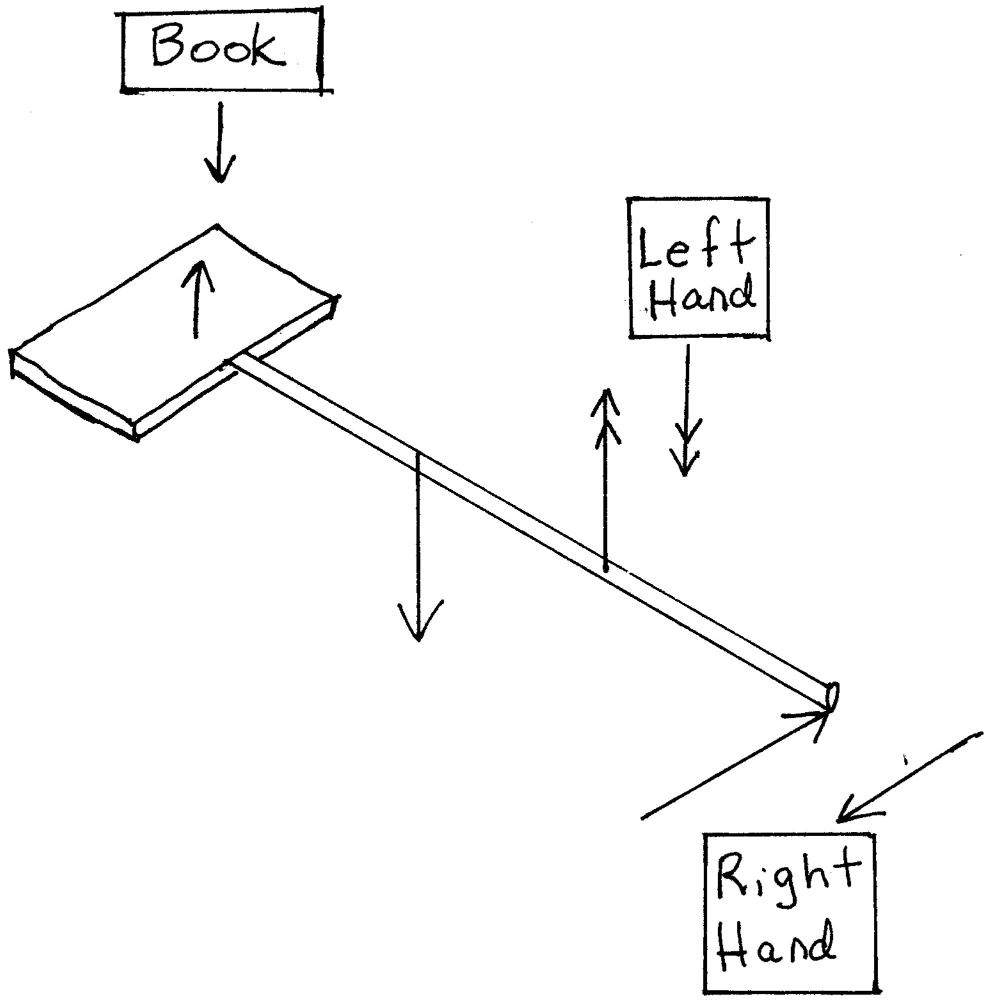
- Draw a free body diagram of only the screw showing all forces and moments acting on it. The forces should account for the detailed way in which the screw actually contacts the screwdriver, and interaction between the screw and the wood. Put "wood" in a box, and draw the force and/or moment exerted by the screw on the wood.

Wrench

Grasp the wrench with your right hand and slide the jaws of the wrench over the head of the bold. By pressing on the end of the wrench, attempt ***very lightly*** to turn the head clockwise (so as to tighten the bolt).

- Draw a free body diagram of only the wrench showing all forces and moments acting on it. (Ignore the interaction between the earth and the wrench.) The forces should account for the detailed way in which the bolt head actually contacts the wrench, and your drawing of the wrench should reflect this detail. Put "right hand" in a box, and draw the force and/or moment exerted by the wrench on your right hand.

- Draw a free body diagram of only the bolt showing all forces and moments acting on it. The forces should account for the detailed way in which the bolt actually contacts the wrench, and interaction between the bolt and the wood. Put "wood" in a box, and draw the force and/or moment exerted by the screw on the wood.



This is a sample diagram for Laboratory #1.

The vectors are completely wrong!!

Isometric Grid Sheets are helpful