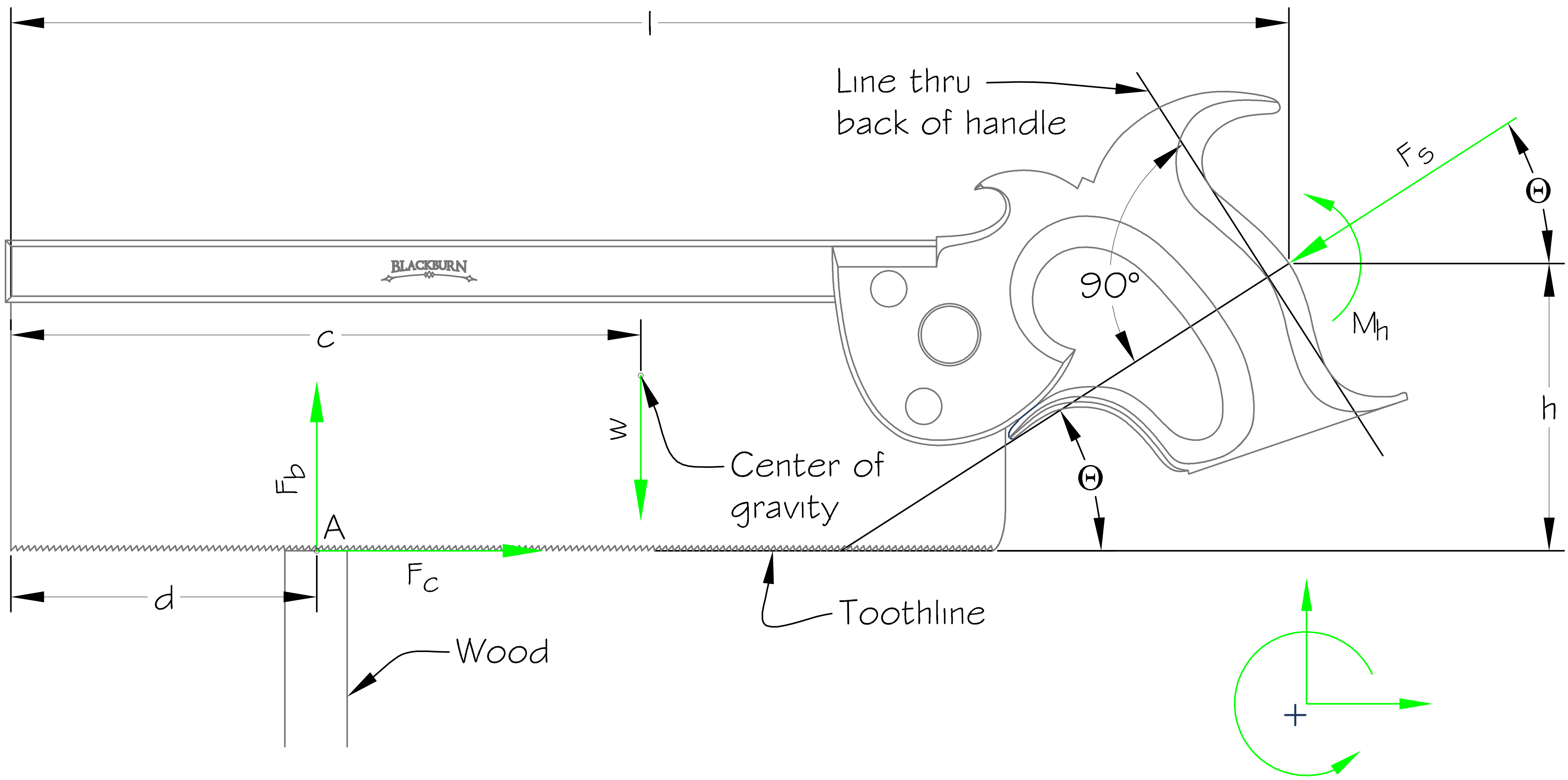

Free body diagram of the forces in a backsaw

Variables

F_s = force, or thrust, applied by sawyer
M_h = moment, or torque, applied by sawyer
F_c = resistance of the wood to being cut
F_b = support from board / downward force on wood at the teeth
w = weight of saw
l = horizontal distance from the toe to the saw to the point of application of F_h
c = horizontal distance from toe of saw to its center of gravity
d = distance from the toe of the saw to the center of the board being cut
h = vertical distance from the toothline to the saw to the point of application of F_h
Θ = hang angle of saw

Assumptions

1. Friction is nonexistent.
2. The toothline is always oriented horizontally.
3. The forces at the teeth act at a single point.
4. The applied force is directed in a line that is parallel to the hang angle. In fact, the angle that the forearm to the toothline is often slightly less than the hang angle, but since this difference is consistent across saws (for any given sawyer), its effect is negligible and does not affect the general conclusions.
5. The applied force is applied at a single point in the center of the grip. It is, in fact, spread out over the grip, and varies across it, but I believe a single point force combined with a moment approximates it closely enough for the purposes of this analysis.

Equilibrium equations

$\Sigma F_x = 0$ Eq. 1: $F_c = F_s\cos\Theta$

$\Sigma F_y = 0$ Eq. 2: $F_b = w + F_s\sin\Theta$

$\Sigma M_A = 0$ Eq. 3: $M_h = w(c - d) + F_s\sin\Theta\ (l - d) - F_s\cos\Theta\ (h)$

While it is certainly possible to solve any or all of these equations for a given saw, it is more instructive and interesting to leave them as is and examine the effects of changing certain parameters and variables.

Changing the hang angle, Θ

Examining Equations 1 and 2, it is apparent that as Θ increases, F_c decreases while F_b increases. That is, a lesser proportion of the applied force, F_s, is used to drive the saw forward, and a greater proportion used to press the saw downwards, biting into the wood.

Looking at this from a different perspective, we can use these results to conclude that increasing the hang angle must increase the applied force, F_s, that is required to both start the saw and keep it in motion.

Decreasing the hang angle will, of course, lead to the opposite conclusions.

Θ_h	cosΘ	sinΘ	F_c	F_b
↑	↓	↑	↓	↑
↓	↑	↓	↑	↓

Table 1. Effect of changing hang angle, Θ.

Changing the weight, *w*

Examining Equations 1 and 2, it is apparent that as *w* increases, F_b increases while F_c remains unchanged. That is, without changing the applied force, F_s, we have increased the force that is pressing the saw downwards, biting into the wood.

For a saw to cut, there must be both a horizontal and vertical force present at the teeth (F_c and F_b in our example). If either of these components are removed, then the saw simply cannot cut.

Consider the case of an imaginary weightless saw that has a hang angle such that $\Theta = 0$. In this case, $F_b = 0$ (Eq. 2), and the saw cannot cut; no matter how great F_s is, the saw will only glide over the wood without cutting. If we either add weight to the saw or increase the hang angle, the saw will begin to cut.

Seeing that F_b can be increased by increasing either *w* or Θ, it should be apparent that as *w* increases, Θ can be decreased without changing the magnitude of F_c (or *vice versa*). It is for precisely this reason that shorter, lighter saws tend to have higher hang angles than longer, heavier saws. In small saws, little of the required downward force comes from the weight of the saw, so the hang angle must be increased to compensate. Conversely, if we were to couple a high angle handle with a long, heavy saw, the downward force would be great enough to cause stalling or difficulty in starting the cut.

We have neglected Eq. 3 in this discussion, but it does not affect our findings. Changing the weight or hang angle will change the magnitude of the moment (torque) that is required to hold the saw horizontally. It is left as an exercise for the reader to work through the effects of these changes.