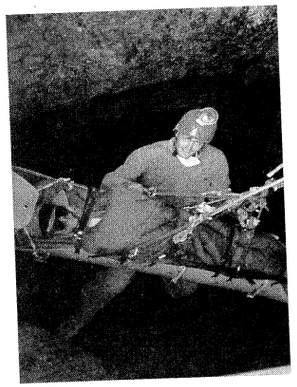


Raising

Raising a climber is never physically easy, but with practice a raising system is not necessarily tough to build. Some raising systems are quite complex, but we will start with simple systems and work our way up. All of the systems are described with the rescuer above the climber, and all systems are described using carabiners as the pulley mechanism.

Times you might want to raise a climber include:

- Giving a quick assist to your second through a short, tough section of the climb.
- Raising one pitch or less in order for a hurt, tired, wet climber to top out the climb.
- When using a crevasse rescue system (to get your partner back to the surface).
- During a multipitch rescue for an injured climber, where it is not possible to descend.

SIMPLE 1:1

A quick and helpful solution to a difficult crux section is to keep a tight belay, which may need to become more of a downright fish fight. The 1:1 pull is definitely effective, and all climbers (and certainly guides) have used it successfully. With good positioning, the lift can happen with the legs. Lock your belay device off while lifting, and then pull in captured rope while the climber fights to maintain his position. This method will not work if the climber can't assist while the belayer captures rope through the belay device.

With the climber above on a top-rope or through a redirect, it is possible to do a counterweight pull by locking your belay device and dropping to a crouch. Then, because of the friction at the top-rope carabiners, it is generally possible to quickly stand up and take in rope at the same time, locking off when standing again. Repeat this sequence. If you need to see this in action, head to the nearest super rad sport-climbing area. There should be plenty of folks using this technique to "work" routes.

DROP-LINE ASSIST 1:1

This next simple system is great for a short hard crux that leads to easier ground. It is not possible to do a drop-line assist if the climber is more than one-third the rope length from the rescuer/belayer. With a second rope you can do this assist with the climber a full pitch away.

Make sure the standing end of the rope is anchored to the master point (MP) (often it already is, if you are clipped in with a figure eight on a bight or clove hitch). Lower the rope stack to the climber. She can now use the rope to pull on as you belay her in. She gets to do the hard work! If she is adept at friction hitches, she can get busy and throw one on the spare line as well, pushing it up the rope as she ascends. You might also want to pre-tie loops before you throw the rope, so she has something to pull on. Simple is good!

DROP A LOOP 2:1

It is possible to convert a drop-line assist to a simple 2:1 pulley assist. However, the farthest the climber can be from you is about 75 feet (if you have two 160-foot ropes), or about 50 feet (if you have only one 160-foot rope).

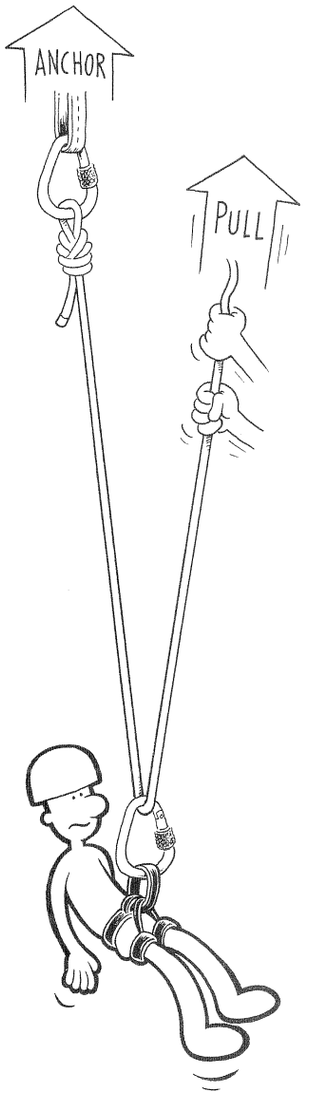
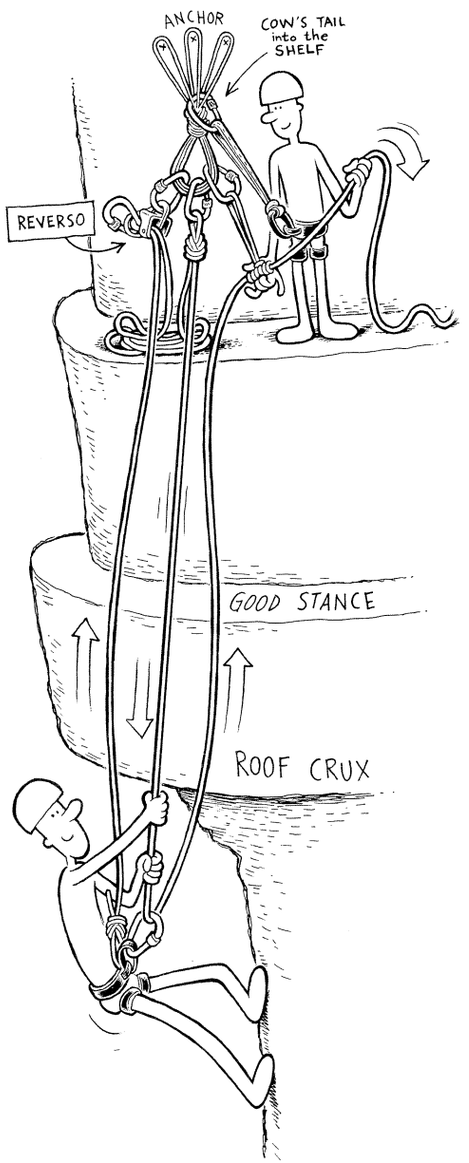


Fig. 6-1. Raising Systems. A simple 2:1



1. Get hands-free: you will need your hands free of the belay for pulling.
2. Doublecheck that the standing end of the rope is attached to the anchor.
3. Clip a carabiner onto the rope stack. The carabiner should slide freely on the rope; do not tie it onto the rope in any way. Drop this rope and carabiner to the climber. Keep hold of the other end of the rope.
4. Have the climber take the carabiner and clip it in to his belay loop.
5. Now you can pull on the unanchored end of the rope you just dropped him. The climber can help by trying to pull on the anchored end of the rope. He should slowly go up.

Caution! The climber is tied off to the belay at his starting height. So if you let go he will drop back down to the tie-off point. For a quick short-aid section, it might be fine to hand-haul. For a longer pull use a Prusik to take in slack or put a locking carabiner with a Munter on the MP or shelf. As you pull up, take in the slack through the Munter. In cases of a long haul (e.g., the rest of the pitch), it would be best to completely escape the belay (since you will not be resuming it).

This 2:1 can also be used in crevasse rescue. It is a good way to get the climber out of a crevasse that has a nasty lip above the climber's original line.

Fig. 6-2. Raising Systems. A drop loop assist is an easy way to create a 2:1.

3:1 SYSTEMS

A 3:1 raising system is a good way to get a climber up a short section without dropping a rope to him. There are a number of variations to building a 3:1: it can be built on the anchor, with a self-blocking belay device, with a Garda hitch, off your harness, and as a complex 3:1 (aka the *Spanish Burton*), which allows for pulling in a downward direction.

It is best to do long raises off the anchor (as opposed to off your harness). If you are building a system specifically to raise someone, there are several things you can do to help yourself out:

- Build the anchor high, mainly so the rope runs cleanly over the edge of the ledge you might be on, but also so you have some room to work.
- If you have pulleys, use them instead of carabiners—one attached to the pulley-point Prusik and one at the anchor pulley.
- Create a *self-tending ratchet Prusik* by putting a belay device (like an ATC) on the loaded line running through the anchor. The ATC will not provide friction, though it will block the ratchet Prusik from flipping through the carabiner through which the climbing rope runs (or from getting sucked up by the anchor pulley if you are not using a specialized Prusik-minding pulley). Creating a self-tending ratchet Prusik saves you the effort of resetting the ratchet and maintaining it. If you do not have a belay device to insert here, you will need to watch the ratchet very carefully.

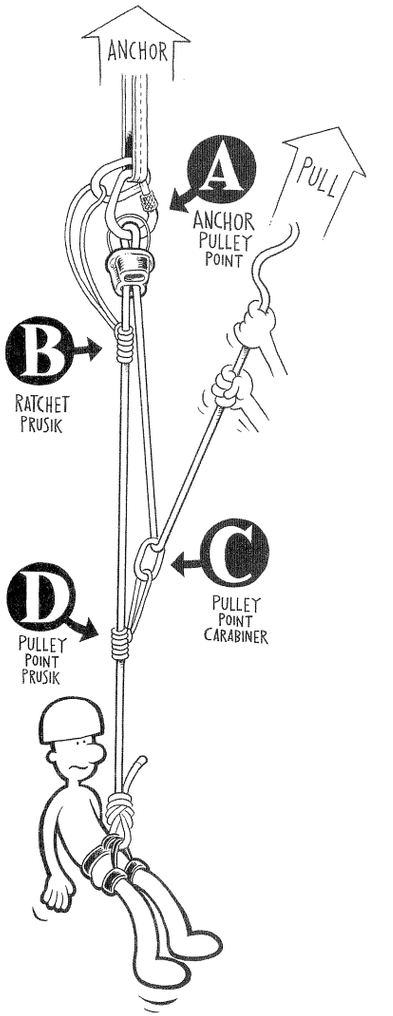


Fig. 6-3. Raising Systems. A simple 3:1. "A" indicates the anchor pulley point, "B" the ratchet Prusik; "C" the pulley point carabiner, and "D" the pulley point Prusik.

3:1 OFF THE ANCHOR

1. If belaying off the anchor, get hands-free. If belaying off your body, escape the belay.
2. Take a rescue loop and tie a Prusik onto the weighted belay strand. Clip the loop into a locking carabiner on the master point or shelf. (This is the ratchet Prusik.)
3. Take another rescue loop and reach forward, down the loaded strand leading to your climber, as far as you can and attach the rescue loop with a Prusik hitch at that point on the line—a "pulley point." (A rescue loop tied in this manner is the pulley-point Prusik.)
4. Clip a locking carabiner to this pulley-point Prusik and then clip the loose brake strand through the carabiner. (If carrying a pulley, use it here instead of a locking carabiner.) Maintain a hand on the brake strand while you complete the remaining steps.
5. If an ATC is available, use it to create a self-tending ratchet. Attach it to the brake strand as close as possible to where the rope exits the Munter-mule-overhand (MMO). Clip a locking carabiner around the rope and through the belay device and attach it to the MP. (This locking carabiner is the anchor pulley.)
6. Transfer the load onto the ratchet Prusik by slowly undoing the mule-overhand and the Munter. Remove the carabiner on which the MMO was tied. Pull in all slack.

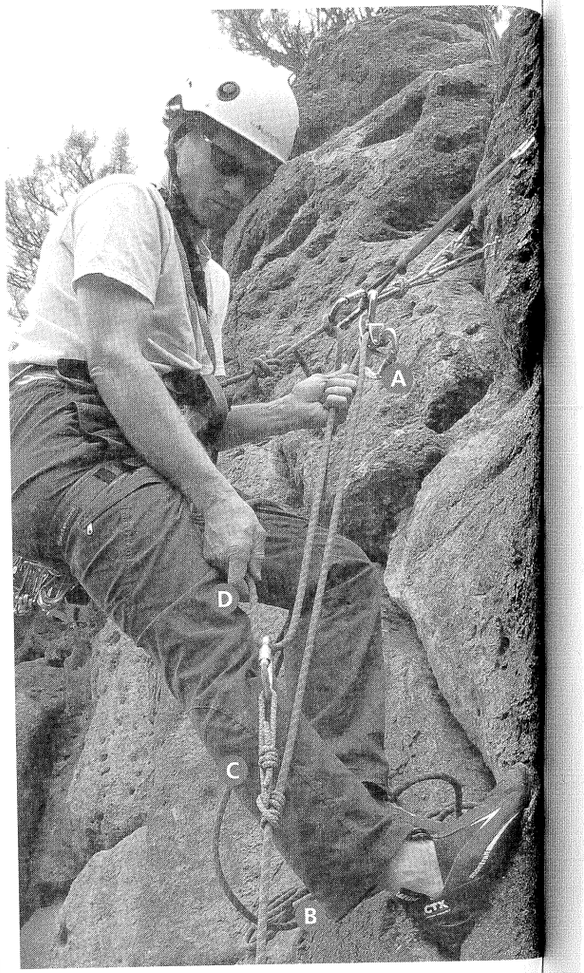


Fig. 6-4. A 3:1 raising system with self-blocking belay device. "A" indicates the self-blocking belay device (which replaces the need for a ratchet Prusik); "B" the load strand; "C" the pulley point Prusik; "D" the haul strand.

7. Once you have removed all slack created by undoing the MMO, you are now ready to haul. As you pull in line you may need to "set" the ratchet by pushing it forward before easing off your pulling. Eventually the pulley-point Prusik will reach your belay device. At this point you will need to reset it.
8. To reset the pulley-point Prusik, ease off the line, letting the ratchet hold the climber's weight, and then push the pulley-point Prusik as far forward as you can. Repeat as necessary.

3:1 WITH SELF-BLOCKING OR LOCKING-ASSIST BELAY DEVICE

If belaying off the anchor with a self-blocking or *locking-assist belay device,* there is no need to set a ratchet Prusik. Simply follow steps 3 and 4 above in "3:1 Off the Anchor." Eventually you will have to reset the pulley-point Prusik, following step 7. Fig. 6-4 shows a 3:1 system with a self-blocking device.

3:1 WITH A GARDA HITCH

Some climbers choose to build a 3:1 with a Garda hitch. This eliminates the need for a ratchet (and ratchet tending). It is fast and easy to set. One major downfall, however, is that this system is not easily reversible.

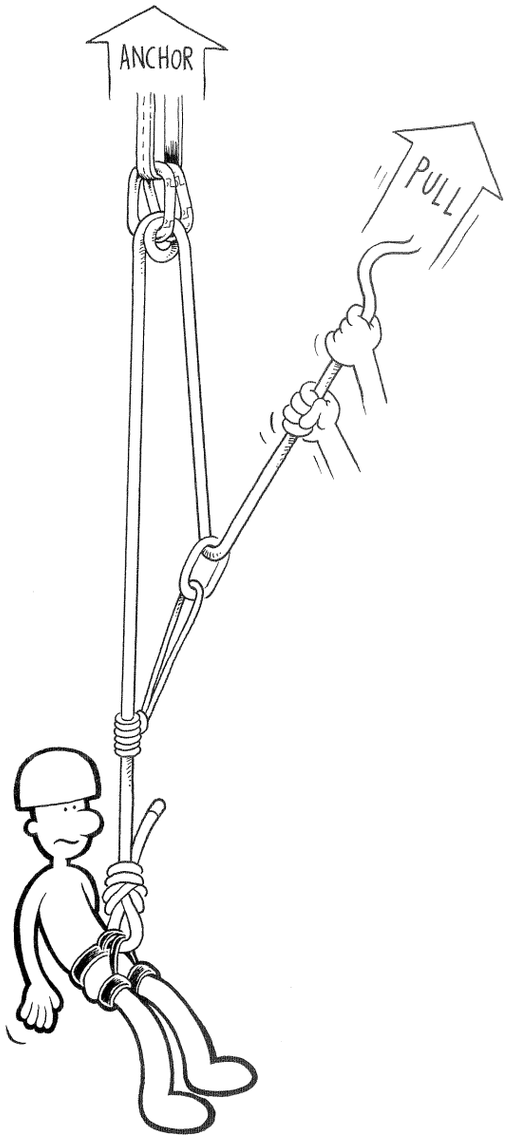


Fig. 6-5. A 3:1 employing the use of a Garda hitch. Note how the Garda is tied; the loop (see "Tying a Garda, step 3" in chapter 2) is clipped into the carabiner that corresponds to the side of the rope that you want holding the load.

PULLEY VERSUS CARABINER EFFICIENCY

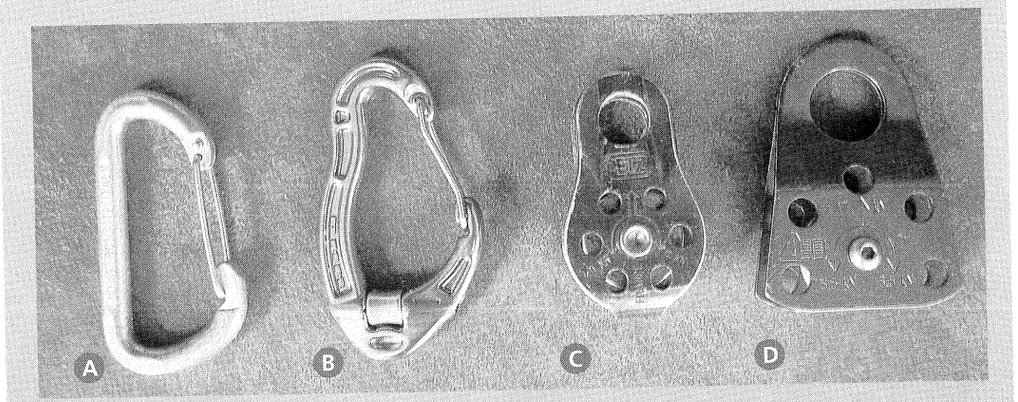


Fig. 6-7. (A) A wire-gate carabiner, (B) A DMM Revolver carabiner, which incorporates a small pulley into the carabiner's base, (C) A basic climbing pulley, and (D) A Prusik-minding pulley.

When a rope runs over or around something, there is friction. The more pronounced the angle of contact, the rougher the surface, and the more weight against the surface, the more the friction. If a rope holding 100 pounds were to run over a surface with an efficiency loss due to friction of 50 percent, you would need to double your effort and pull with 200 pounds of force in order to raise the load. Friction is our enemy in mechanical advantage systems. It makes us work harder and it puts higher forces on our gear than if we were working in a frictionless world. Different combinations of ropes and carabiners, along with the actual forces in play, will result in different friction coefficients.

Below we list efficiencies for carabiners and pulleys. This is intended for general information purposes and does not apply to all situations or all combinations of gear.

Oval carabiner: 70 percent
DMM's Revolver: 75–80 percent
Basic climbing pulley: 80–85 percent
High-quality rescue pulley: 90+ percent

What efficiency percentages mean: If a carabiner has 70 percent efficiency and we are raising 100 pounds with it on a 2:1 system, we will have to lift with 59 pounds (not getting into static friction coefficients and rope-stretch details). If we are using a 3:1 system and there are two carabiners in the system, we will have to pull with 46 pounds—far from the 33.3 pounds of the frictionless world!

Note the diminishing returns as well. The more carabiners we add to the system, the smaller the gain. The forces on our gear keep going up, but we get less out of the system because the inefficiencies add up. Interestingly, when we stack a 3:1 on a 3:1 using carabiners to build the system, we need to input 21 pounds to lift 100. If instead we stack a 2:1 on a 3:1, we need to input 27 pounds to lift 100. Not much difference. These systems are supposed to be 9:1 and 6:1 respectively but a lot of force is lost through friction!

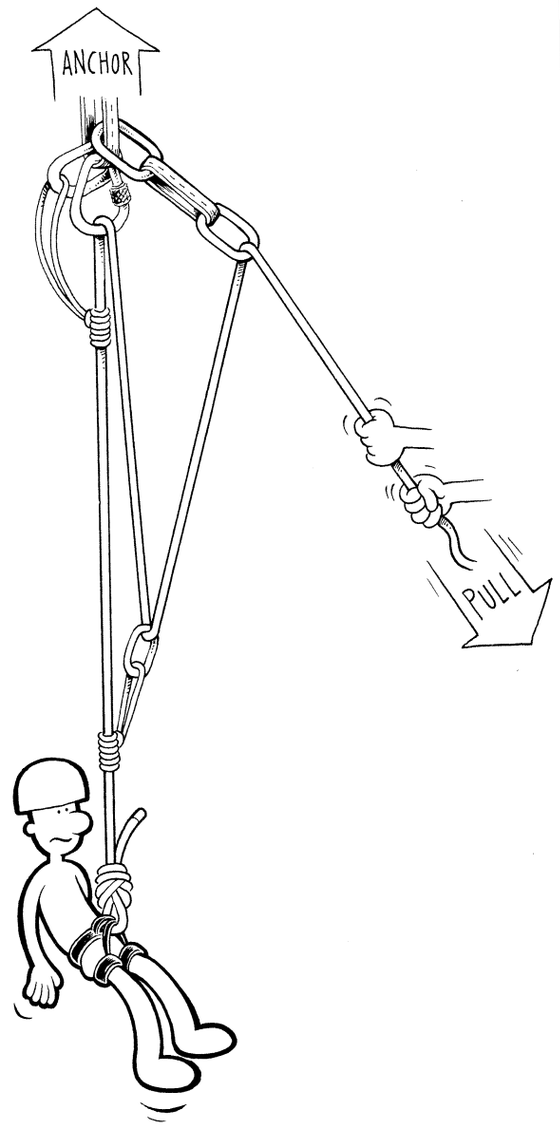
This highlights the difference between *ideal mechanical advantage* (e.g. 9:1) and *theoretical mechanical advantage:* the resulting mechanical advantage once friction generated by pulleys, carabiners, cliff edges, etc. is accounted for. Because of the amount of efficiency lost to friction it is not always worth building more involved systems unless you have high quality pulleys.

IF YOU NEED MORE!

How large a system do you want? We already said simple is better and we know friction is eating away at our efficiency (especially if we are using carabiners instead of pulleys), but what system will be enough to get the job done? Here are a few more points to consider with raising systems.

Mechanical advantage or change of direction? Mechanical advantage explains how work is spread out over time and distance. For the purposes of improvised self-rescue, "mechanical advantage" can be thought of in these simplified terms: with a mechanical advantage ratio of 3:1, for every three feet of rope pulled through the system, your patient will be raised one foot. With a 9:1, for every nine feet of rope pulled through the system your patient will be raised one foot. When building a mechanical advantage system, if the last pulley is attached to the anchor and is *not* moving, it is not helping with the mechanical advantage. Instead, it is termed a "change of direction." This is good if you want to pull down instead of up, but not if you are concerned about friction. It is only adding more friction to the system, not any mechanical advantage. That being said, do not be afraid to add a change of direction to any of your systems, if it will help. Note the Spanish Burton: the last pulley is moving so it *is* helping with mechanical advantage.

How big do you go? In the sidebar "Pulley versus Carabiner Efficiency" we give some real-world numbers relating to input effort for different systems to raise a 100-pound load. These numbers merely look at friction at the pulley points and do not look at friction or losses throughout the rest of the system. Building a wonderful 3:1 to pull up our 200-pound buddy is not such a rosy picture when we look at all



the losses in the system. If the rope runs sharply over an edge, say a 90-degree bend (ouch!), you can lose as much as 50 percent of your effort. That means if you have a 3:1 built with climbing pulleys (83 percent efficiency), and your rope runs over a bare rock edge down to the 200-pound patient, you need to pull with 120 pounds! You would only have to pull with 80 pounds if that edge was not there. (Reducing edge angles is another reason to rig high.)

One easy way to increase your system's efficiency is to replace carabiners used as pulley points with actual pulleys. Some climbers would say you are foolish to head up a long multipitch climb without a pulley. This simple substitution reduces a large amount of friction in the system. (DMM's Revolver—a carabiner with a small, built-in pulley—is a lightweight solution). If you are dealing with obstacles like sharp edges, don't forget to consider protecting your rope with some impromptu edge protection: extra clothes, a pack, an ice ax shaft, and so on. Remember to secure the item to the anchor.

Fig. 6-8. Because the quickdraw coming off the anchor is stationary it does not add mechanical advantage to this 3:1 pulley. All the quickdraw does is provide a change of direction so that the belayer can pull downwards. Because of the added friction the change of direction carbiner creates, it would make more sense to raise with a Spanish Burton (a 3:1 that already incorporates a downward pull).

Keeping the system clean, simple, and straight will get you more bang for your effort than adding advantage with pulleys to an inefficient system. But if inefficiencies are unavoidable, then yes, you may need to look at adding more mechanical advantage. Note also that the forces you are putting on your anchor when raising are much higher than in normal climbing scenarios. Do you need to beef up your anchor? If you pull on a system and there is something stuck, like a knot in a crack, and you continue pulling, the forces exerted on the anchor could skyrocket. A good rule of thumb when building these systems is that you should definitely be able to feel the load when you pull on the system; this also helps safeguard against pulling your patient up through an obstacle (a ledge, vegetation, a crevasse lip, a stuck section of rope, etc.), which could result in serious injury and putting undue forces on the anchor.

TURNING A SIMPLE 3:1 INTO A COMPLEX 5:1

This is a nice little system that allows you some more mechanical advantage: a 5:1, with just a little adjusting.

1. Clip a long single strand length of webbing or cord through your anchor's shelf. (The longer the piece of webbing the better.)

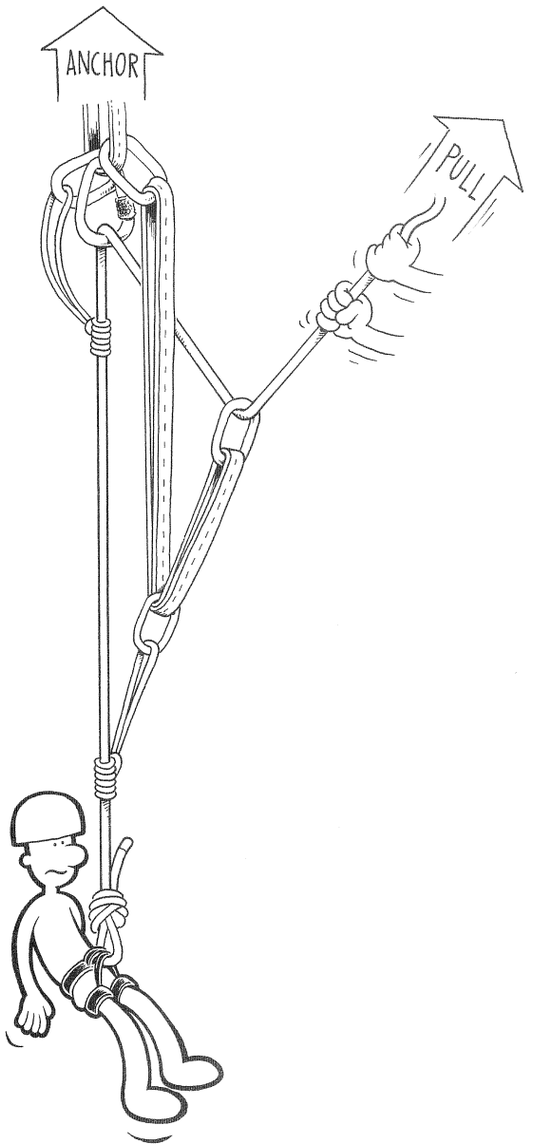


Fig. 6-9. A complex 5:1. A 3:1 can be quickly turned into a 5:1 with the addition of just two carabiners and a piece of webbing.

2. Clip the webbing through the carabiner attached to the pulley-point Prusik.
3. Clip the haul line through a carabiner attached to the other end of the webbing strand. (See fig. 6-9.)

MULTIPLYING ADVANTAGE

The basic 2:1 and 3:1 are excellent for the majority of needs; sometimes you might want a system with bigger mechanical advantage, like the 5:1 systems described above. It is also possible to gain much more advantage, without making the system too involved, by stacking systems. If you build a 2:1 to pull (act on) a 3:1, you get a 6:1—the advantage is multiplied. So if you pull on a 3:1 acting on a 3:1, you get a 9:1. That's a lot of force! Again, your anchors need to be able to handle the forces you create; and the forces are higher than ideal due to friction in the system. Friction in the system also makes the higher mechanical advantage systems much less efficient unless you include some pulleys in place of carabiners.

Generally, on a small rock ledge space is an issue, so stacking systems is tough to do. On a glacier there is more space to work, so it is easier to build bigger, more complex systems. Keep it simple. It is often more efficient to pull harder than it is to add more carabiners (friction) and bends in the rope (friction).

Raising systems can get quite involved, and we do not discuss the more complex systems that may be used in larger rescues.

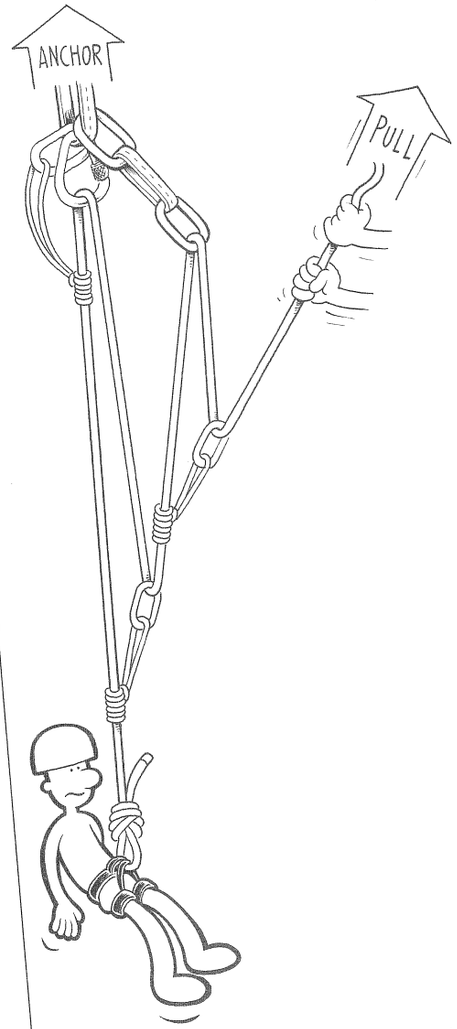


Fig. 6-10. Raising System. A compound 9:1. A 3:1 acting on a 3:1.

In reality, the 2:1 and 3:1 presented above should take care of a majority of small-party rescue situations. If you need more complex systems, you also may need more people and more gear than you have with you. Just because you can build it does not mean your equipment can handle it. Remember to tie off the original system when you are in the process of adding advantage.

BUILDING A 2:1 ACTING ON A 3:1

1. Take a long sling, cord, or the standing end of the rope. Clip it directly to the anchor.
2. Tie a Prusik with a rescue loop on the haul line of the 3:1 and clip a locking carabiner to it (this is a second, new pulley-point carabiner).
3. Clip your new piece of sling/cord/rope (introduced in step 1) through the new pulley-point carabiner.
4. Push both pulley-point carabiners down the lines as far as possible while the ratchet Prusik holds the load.
5. Haul on the new piece of sling/cord/rope.
6. You are now using a compound 6:1. Reset the pulley-point Prusiks as necessary.

BUILDING A 3:1 ACTING ON A 3:1

1. Clip a locking carabiner in to the MP or shelf of your anchor.
2. Slide the pulley-point Prusik down the rope as far as possible.
3. Tie a Prusik with a rescue loop on the haul line of the 3:1 and clip a locker to it (just as in step 2 of "Building a 2:1 Acting on a 3:1").
4. Clip the haul line through the new locker on the anchor and then run it back down and clip it through the locker on the rescue loop.
5. You now have a compound 9:1. Pull and reset the pulley-point Prusiks as necessary.