

Chapter 10: Descending/Ascending

Scope: This chapter serves as an introduction to descending and ascending techniques and the use of descent control devices.

Terminal Learning Objective (TLO): At the end of this chapter, the student will be aware how to complete a slow, steady descent and then ascend under controlled conditions.

Enabling Learning Objectives (ELO):

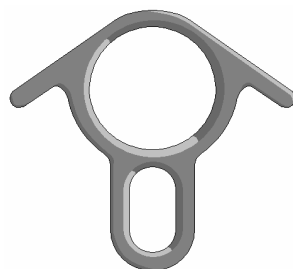
1. Describe ascending and descending techniques
2. Demonstrate how to construct a fixed line for a rappel
3. Demonstrate how reeve a figure eight descender and brake bar rack
4. Demonstrate a rappel and lock-off using a figure eight descender and brake bar rack
5. Demonstrate how to ascend a fixed line and escape jammed friction devices

Descending

Descending, or what is more commonly referred to as rappelling, is a seldom used element of low angle rope rescue. In most situations, it is better to lower rescuers to an incident; however, on occasion, a rescuer needs to rappel to access the site. For instance, a fixed (rappel) line may be necessary when multiple rescuers are needed quickly at the bottom of a slope. Rappelling is a valuable skill that teaches the use of different rescue equipment and builds confidence in the rescuer's ability, equipment, and team capability. Rappelling is a dangerous activity, however, and must be completed under controlled conditions. A proper rappel is a slow, controlled walk down the slope. A slow, steady descent is much easier on ropes and anchors and prevents serious heat buildup from friction that can damage nylon ropes. A fast, bounding rappel has no place in the rescue service and only serves to overheat the descent control device (DCD) and shock load the anchors and their components.

Types of Descent Control Devices (DCD)

Figure Eight Descender (Eight Plate)

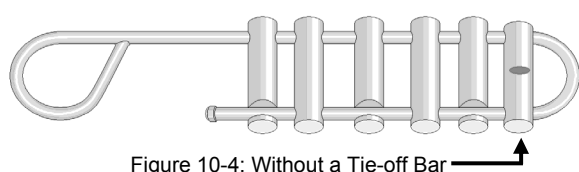
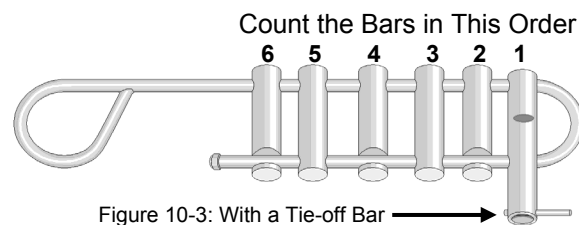


10-1: With Long Ears



10-2: With Short Ears

Brake Bar Rack



Rigging a Fixed Line

- Attach a RPM to a suitable anchor.
- Always tie a figure eight stopper knot in the end of any rappel line.
 - This reduces the potential for rappelling off the end of the line.
- Pay out enough line to reach the desired location.
- Reeve line through the DCD on the RPM.
 - Maintain a minimum 20-foot tail in the fixed line.
 - Lock-off the DCD (illustrated later in this chapter).
 - Form a figure eight on a bight with the tail near the DCD and clip onto the open hole of the anchor plate using a separate carabiner, maintaining 2 feet of slack.

Belay/Safety Line

- The anchor must be located inline with the main line.
 - This prevents a pendulum action if the main line fails.
- Construct a belay/safety line system.

Line Attachments

The rescuer dons a pelvic harness, positions a safe distance from the edge, and faces the anchor with the fixed/rappel line on the right side. The belay/safety line and DCD should attach to separate carabiners at the rescuer's harness.

- Belay/safety line.
 1. Tie a figure eight on a bight in the end of the belay/safety line.
 2. Attach the figure eight on a bight to the rescuer's harness.
- Fixed/rappel line.
 1. Reeve DCD.
 2. Ensure DCD is secured to the rescuer's harness.

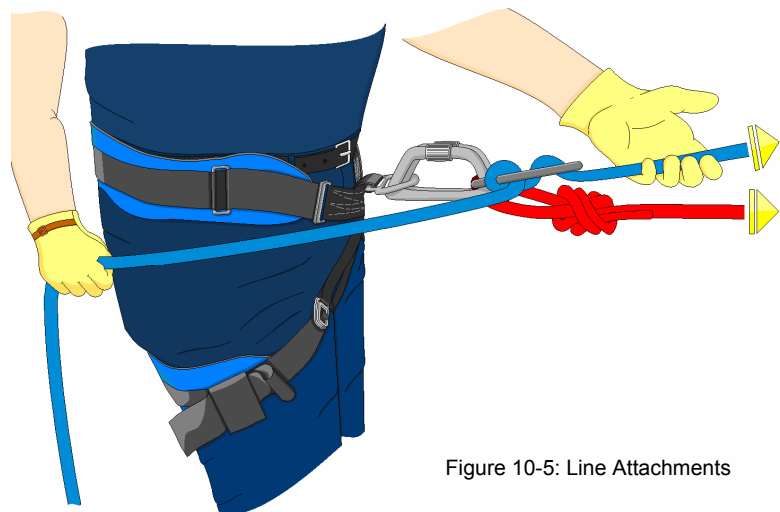


Figure 10-5: Line Attachments

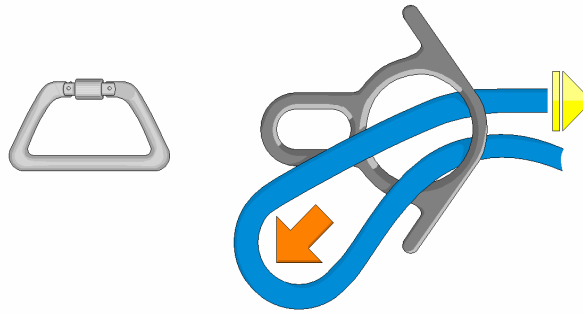
Figure 10-5 depicts the rescuer with main line and belay/safety line attachments. The remaining graphics have the belay/safety line omitted for clarity.

Reeve the Figure Eight Descender

The figure eight descender is shown being reeved for right-handed operation. For a left-handed rescuer, the belay safety line carabiner must be attached to the right side of the figure eight carabiner. Attention must be given to keeping the belay/safety line running clear of the main line. It is because of this potential problem that some agencies encourage or require right-handed operations in rappelling evolutions.

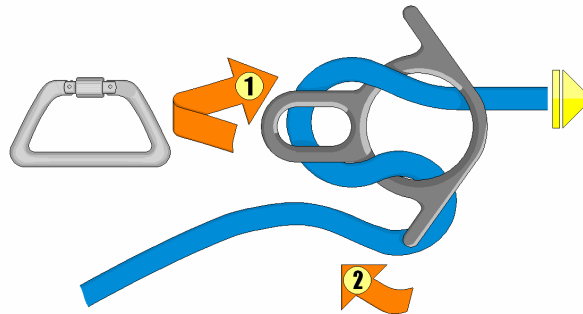
1. Form a bight in the fixed line and pass it toward you through the large hole.
 - Some agencies may choose to pass the bight through the opposite direction. This will affect the lock-off procedures described later in this chapter.

Figure 10-6: Step 1



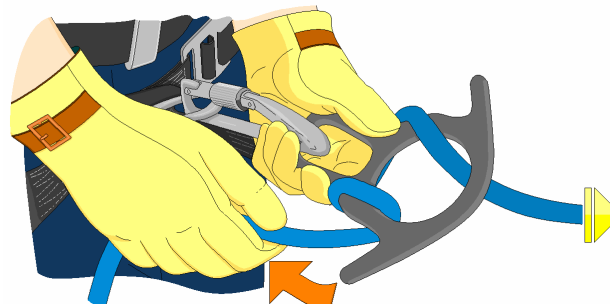
2. Pull the bight through and pass it over the smaller portion of the descender.

Figure 10-7: Step 2



3. Attach the figure eight descender to the harness with a carabiner.

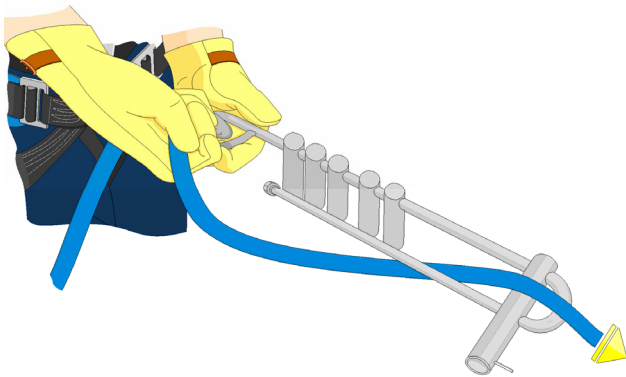
Figure 10-8: Step 3



Reeve the Brake Bar Rack

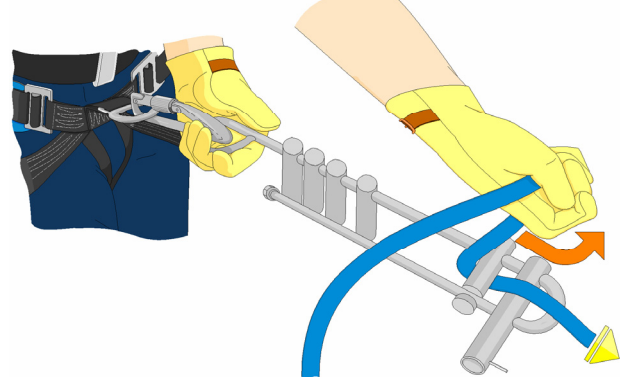
1. Attach the brake bar rack to the harness with a carabiner.

Figure 10-9: Step 2



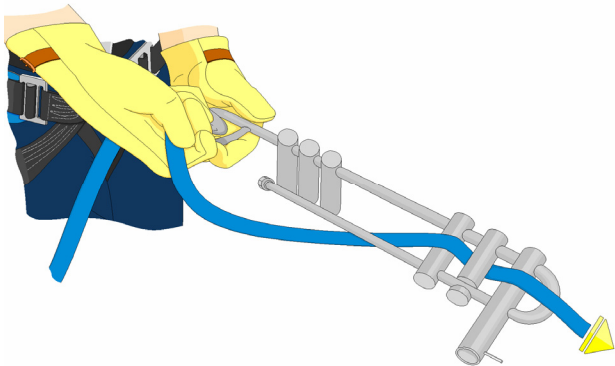
2. Lay the fixed line in the groove on the first bar on the rack.
 - Allow the line to pass through the opening of the rack.

Figure 10-10: Step 3



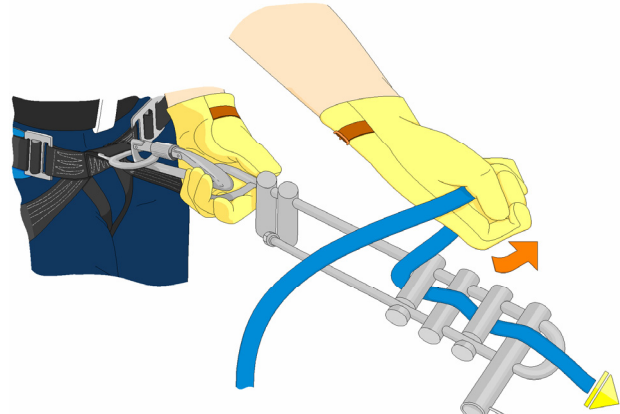
3. Flip the second bar over and snap it onto the rack with the line between the first and second bars.
 - Pull the line back through the opening of the rack, wrapping the second bar.

Figure 10-11: Step 4



4. Flip the third bar over and snap it onto the rack with the line between the second and third bars.
 - Pull the line back through the opening of the rack, wrapping the third bar.

Figure 10-12: Step 5



5. Repeat until the desired amount of bars/friction has been achieved.
 - Friction may be adjusted during the descent by adding or removing bars.
 - Four bars minimum for one (1) person.
 - Five bars minimum for two (2) or more people.

Rappel Position

The rescuer's lower body should always be perpendicular to the slope, with both feet flat on the surface, in order to maintain footing and tension on the system. This perpendicular position needs to be maintained if there is any change in the angle of the slope during the descent.

Hand Position

The hand position changes depending on the DCD.

Figure Eight Descender

- Brake hand.
 - Grasps the rope.
 - Pulls it tight around the hip.
 - Holds it tight with the fist positioned at the buttocks.
- Control hand.
 - Positioned either in front of the descender or just below it to help control the body posture.
 - This is considered to be the full brake position.
 - The friction can be decreased by moving the braking hand away from the buttocks and hip while stepping backwards until the desired speed is achieved.

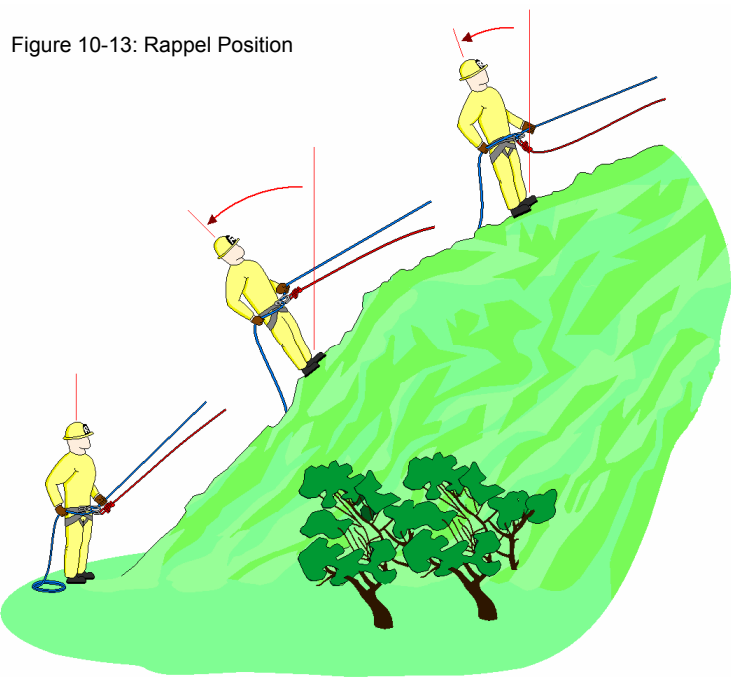


Figure 10-13: Rappel Position

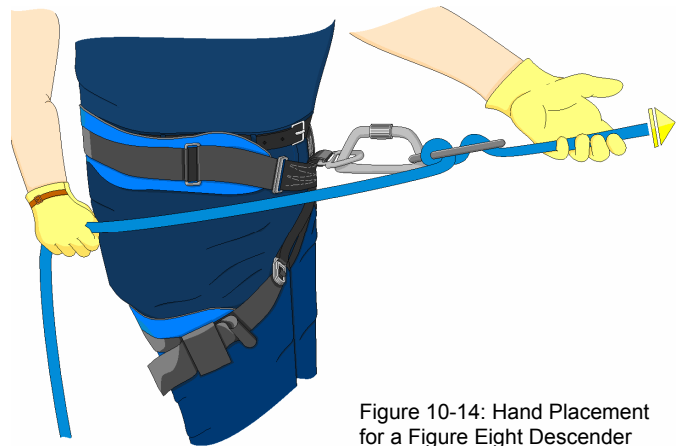


Figure 10-14: Hand Placement for a Figure Eight Descender

Brake Bar Rack

- Brake hand.
 - Grasps the rope where it comes out of the bottom of the rack.
 - Wraps it around either the 4th or 5th bar.
 - Depending on the weight of the rescuer and the angle of the slope.
 - It is always better to begin a rappel with more bars and remove them if necessary rather than not enough.
 - The brake hand is kept in the twelve o'clock position above the rack.

□ Control hand.

- Positioned underneath the rack cradling the bars.
 - This is considered to be the full brake position.
- Friction is varied by moving the braking hand from the twelve o'clock to the five o'clock position and spreading out the bars on the rack with the control hand while stepping backwards.

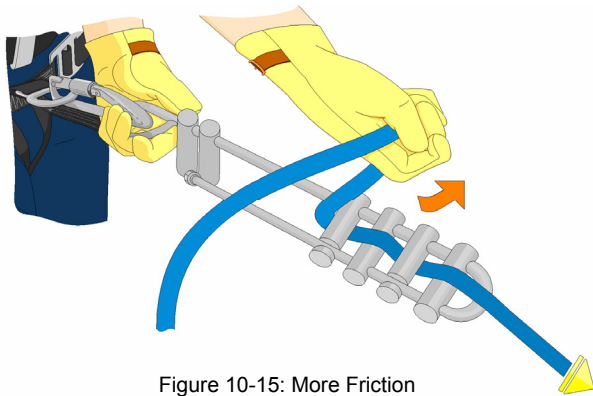


Figure 10-15: More Friction

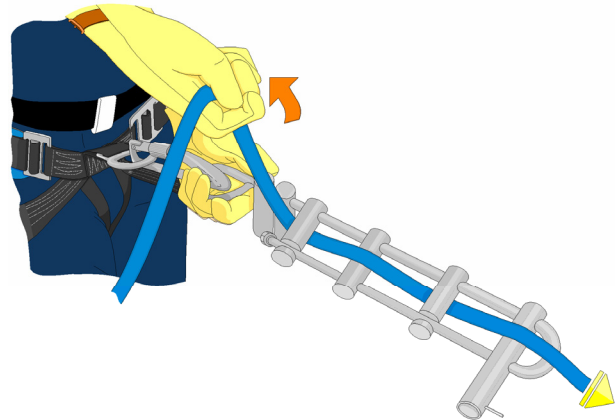


Figure 10-16: Minimum Friction

- The friction can be varied by adding or removing bars until the desired speed is achieved.
- Once the desired speed has been achieved, the control hand may be positioned either in front of the descender or just below it to help control the body's posture.

Departure

Once in the rappel position, the rescuer needs to communicate with the belayer to ensure readiness. Once on belay, the rescuer begins walking backwards to the edge. The rescuer maintains the rappel or full brake position with his or her hands. The rescuer also maintains tension on the fixed/rappel line when walking backwards. Another rescuer can assist the rappeller's transition over the edge by pulling on the line between the rappeller and the anchor to remove any slack and provide tension. This maneuver is known as a "vector pull." When the rappeller is ready to depart over the edge, the rescuer conducting the vector pull eases the rope forward until all the tension in the line has been released. The rappeller is now ready to adjust the friction and begin rappelling.

Lock-off

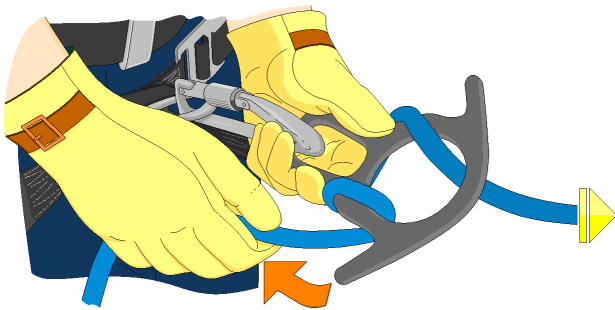
During a rappel, it may be necessary for the rescuer to stop the descent to perform work, package a victim, or to rest. It is necessary to lock-off the descender, whether it is a figure eight descender or a brake bar rack, until the rescuer is ready to continue the descent. Locking-off enables the rescuer to hang suspended on the main line and have the hands free to perform a function with a degree of safety. When the rescuer is ready to descend, he or she simply reverses the lock-off procedure and continues the descent.

Figure Eight Descender with Long Ears

Lock-off with Two Half Hitches

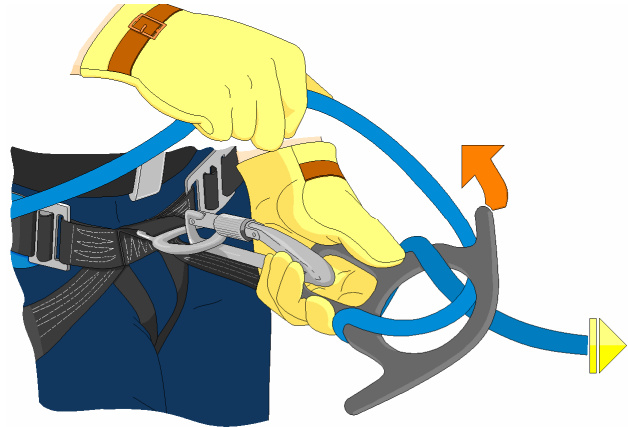
1. Allow the brake hand to move from the back of the hip to the front and hold tight when the desired lock-off point has been reached.

Figure 10-17: Grasp the Connection Point



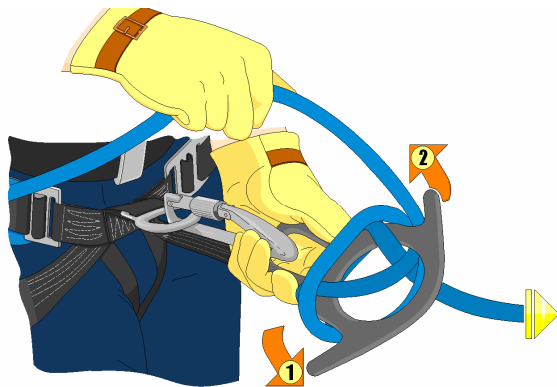
2. Grasp the connection point where the descender meets the carabiner with the control hand and rotate the descender towards the brake hand.

Figure 10-18: Pull the Running End of the Rope



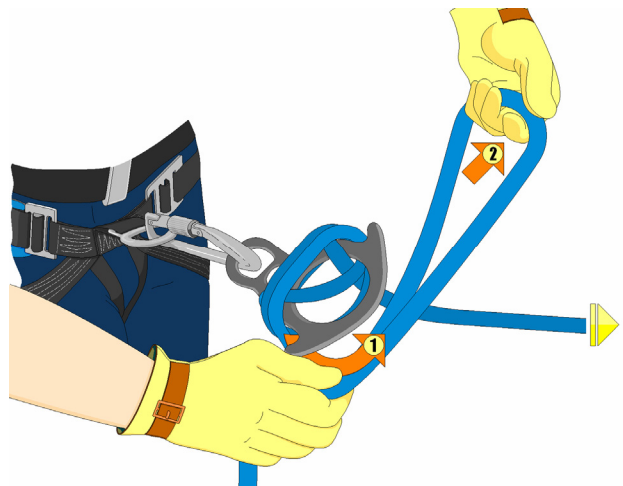
3. Pull the running end of the rope up and across the back of the descender between the standing part and the descender with the brake hand until it pops between the large hole in the descender and the main line.

Figure 10-19: Wrap the Running End



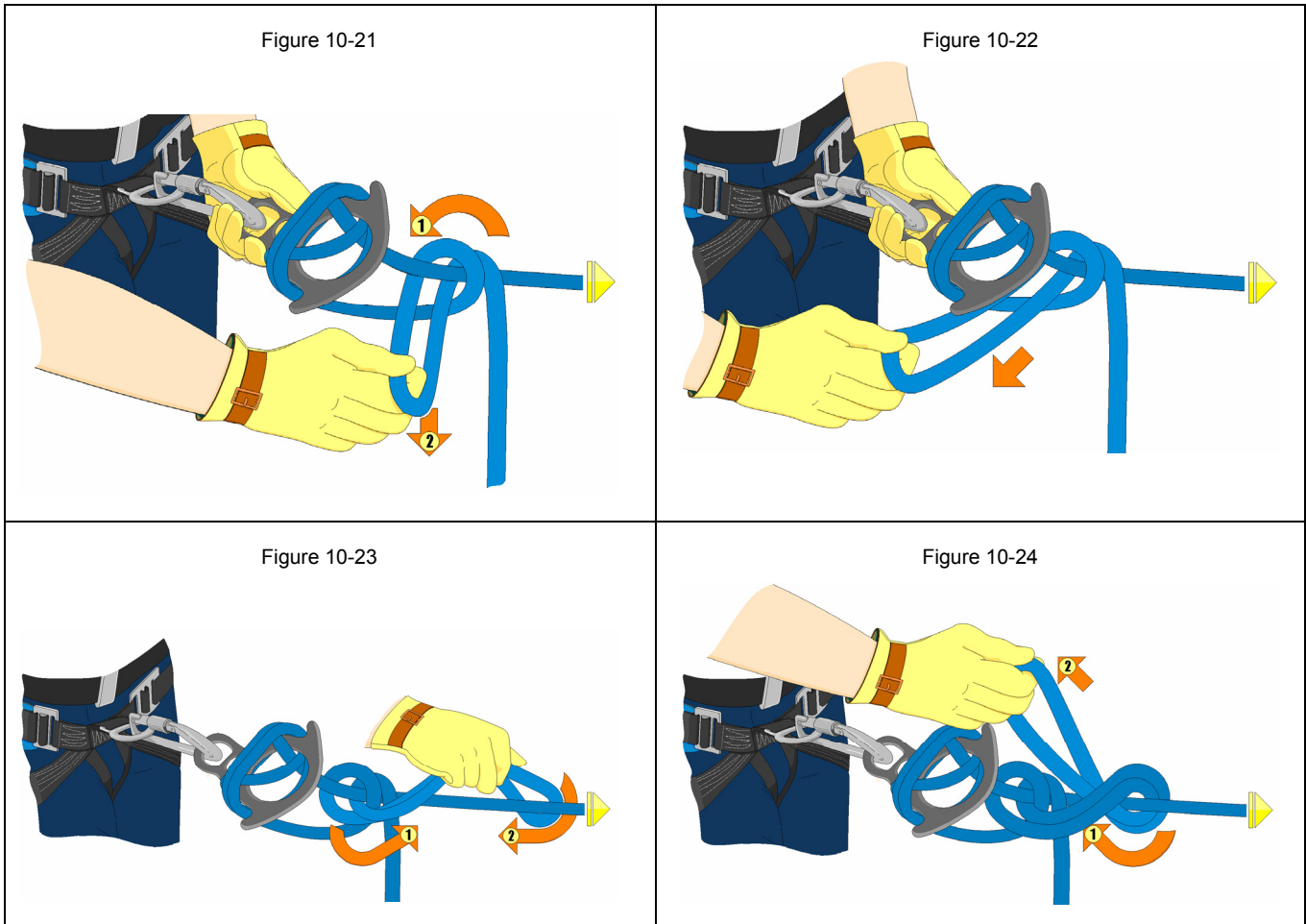
4. Wrap the running end for a second time around the front of the descender below both ears and repeat the step above until it pops between the large hole in the descender and the main line.

Figure 10-20: Continue Wrapping



5. Continue wrapping the running end across the front of the descender, under the right ear to form a long bight across the standing part of the line.

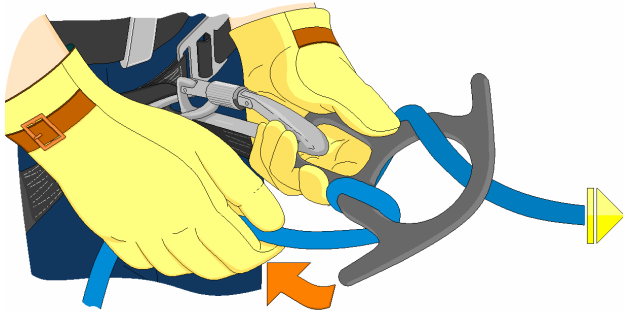
6. Use the long bight to form two half hitches on the standing part of the line. (Figures 10-21 through 10-24)



Lock-off with a Girth Hitch

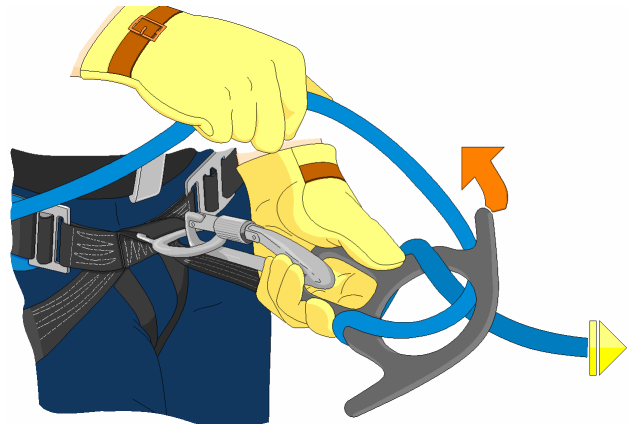
1. Allow the brake hand to move from the back of the hip to the front and hold tight when the desired lock-off point has been reached.

Figure 10-25: Grasp the Connection Point



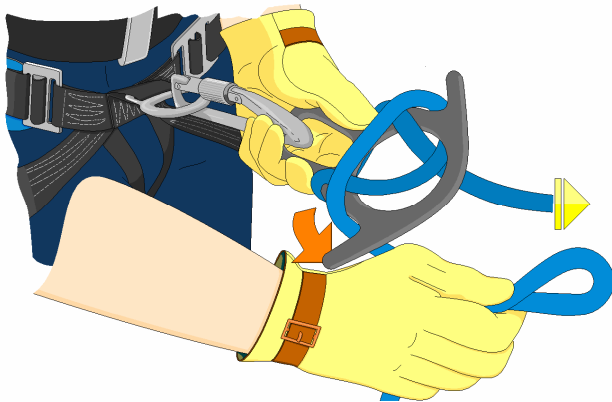
2. Grasp the connection point where the descender meets the carabiner with the control hand and rotate the descender towards the brake hand.

Figure 10-26: Pull the Running End of the Rope



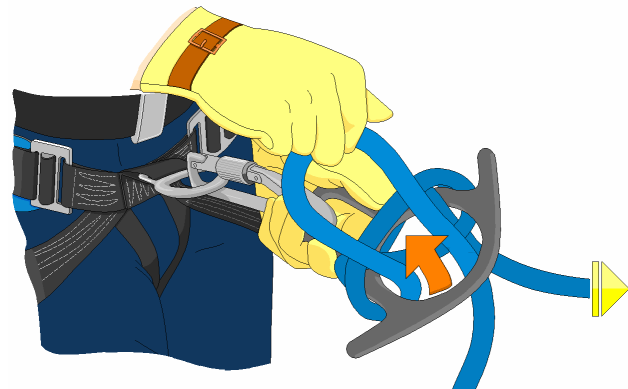
3. Pull the running end of the rope up and across the back of the descender between the standing part of the rope and the descender with the brake hand until it pops between the large hole in the descender and the main line.

Figure 10-27: Continue Wrapping



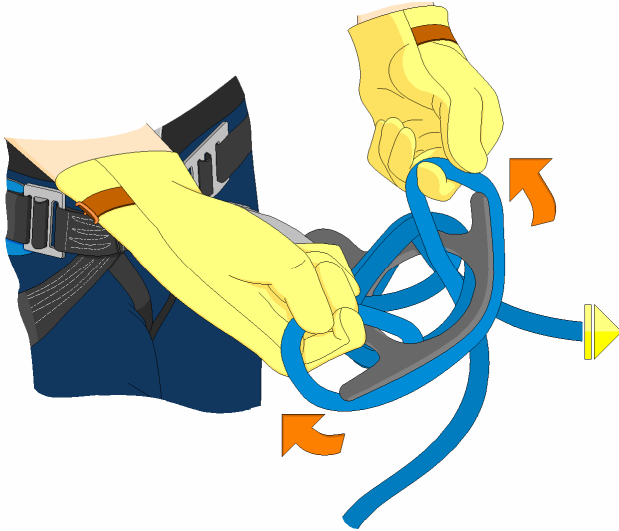
4. Continue wrapping the running end around the front of the descender below both ears and form a short bight along the standing end of the line.

Figure 10-28: Pass the Short Bight



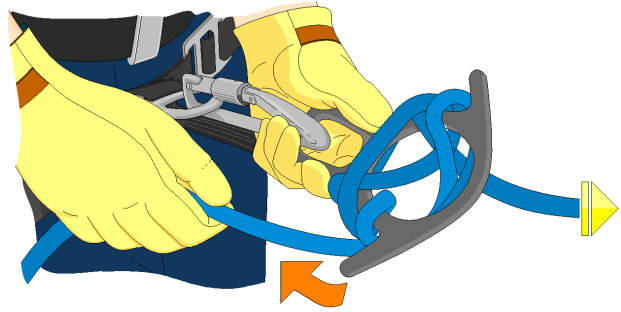
5. Pass the short bight through the back of the descender toward the rappeller.

Figure 10-29: Pass the Bight over the Rope



6. Pass the bight over the top of the descender forming a girth hitch around the descender.

Figure 10-30: Pull the Running End to Tighten

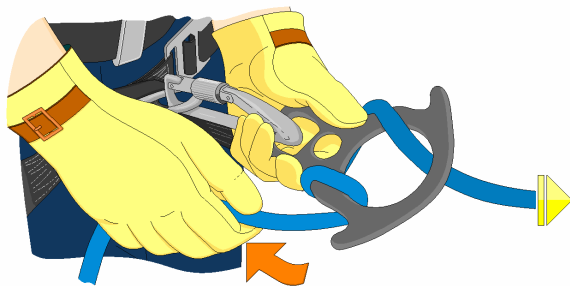


7. Pull the running end to tighten the girth hitch.

Figure Eight Descender with Short Ears

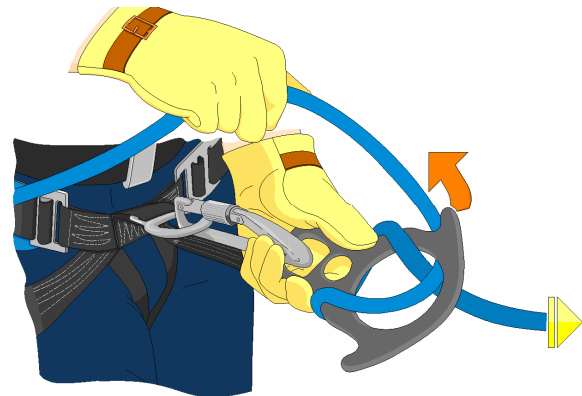
1. Allow the brake hand to move from the back of the hip to the front and hold tight when the desired lock-off point has been reached.

Figure 10-31: Grasp the Connection Point



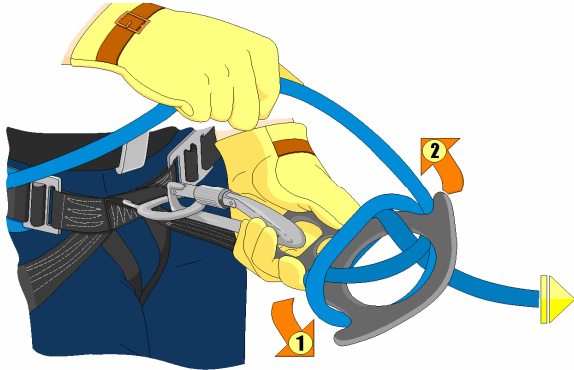
2. Grasp the connection point where the descender meets the carabiner with the control hand and rotate the descender towards the brake hand.

Figure 10-32: Pull the Running End of the Rope



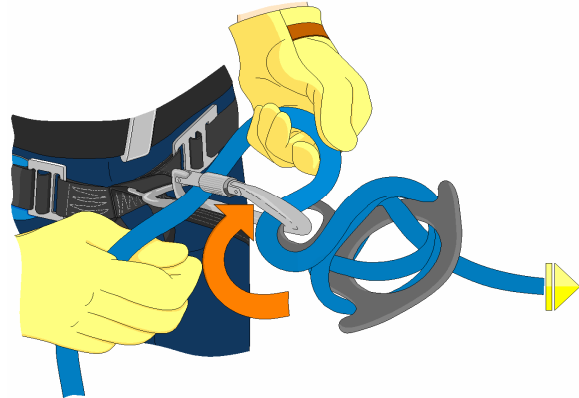
3. Pull the running end of the rope up and across the back of the descender between the standing part of the rope and the descender with the brake hand until it pops between the large hole in the descender and the main line.

Figure 10-33: Wrap the Running End



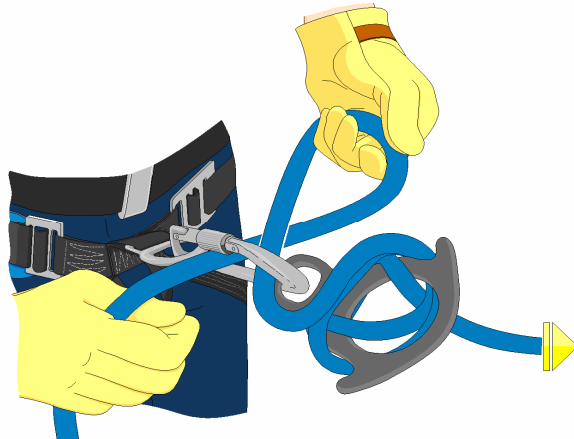
4. Create a second wrap around the descender by repeating Step 3. Pull the line firmly to set both wraps.

Figure 10-34: Pull the Line to the Right



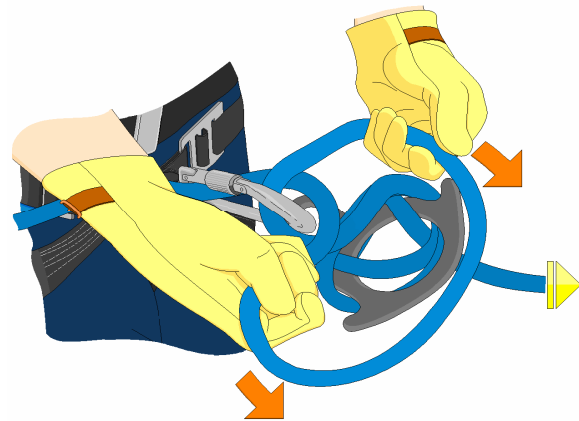
5. Pull the line to the right, across the neck of the DCD, and through the carabiner from right to left to form an 8"-10" bight.

Figure 10-35: Twist the Bight Clockwise



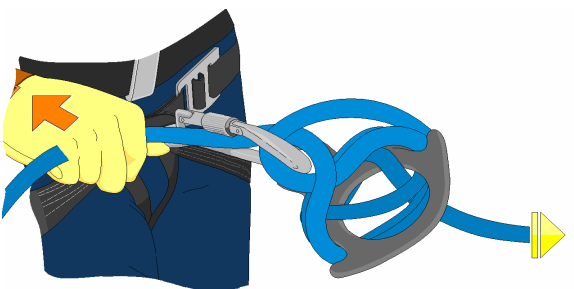
6. Twist the bight as shown to form a loop.

Figure 10-36: Pass the Loop over the Top



7. Pass the loop over the top of the descender.

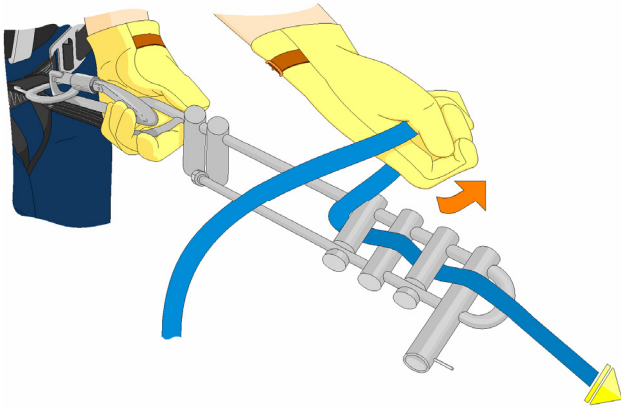
Figure 10-37: Pull the Running End to Tighten



8. Pull the running end to tighten the loop.

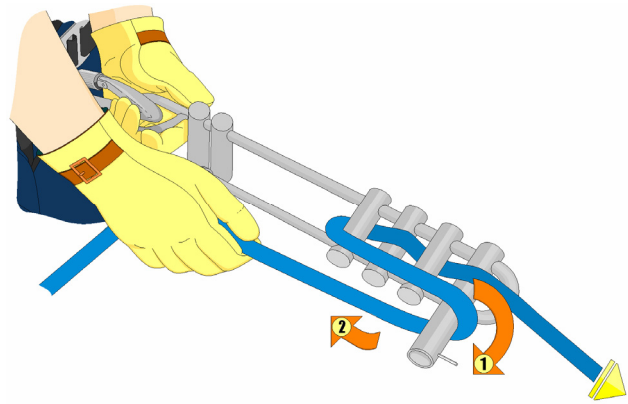
Brake Bar Rack with a Tie-off Bar

Figure 10-38: Position Hands



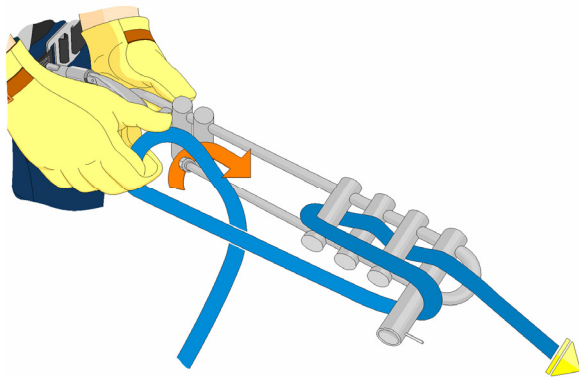
1. Position hands in the full brake position.

Figure 10-39: Wrap the Running End



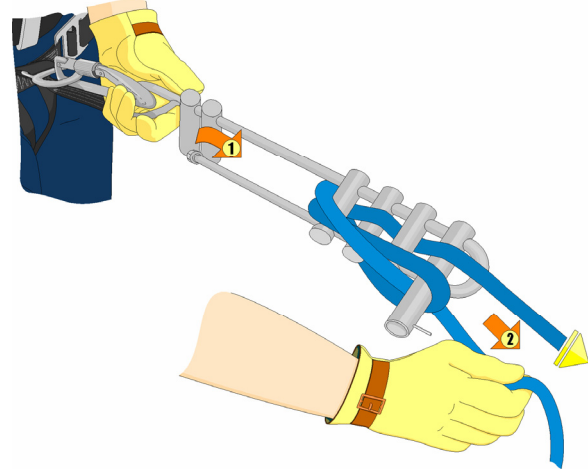
2. Wrap the running end around the tie-off bar with the brake hand.

Figure 10-40: Form a Half Hitch



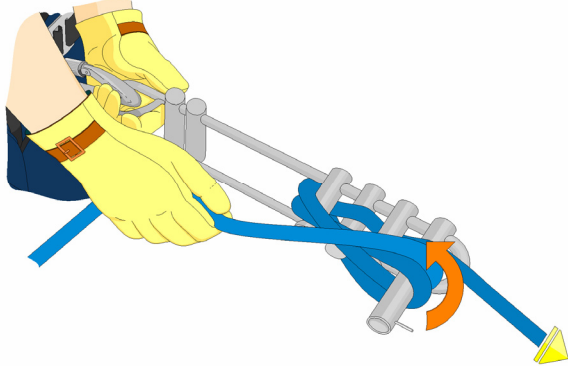
3. Form a half hitch in the running end near the opening of the rack.

Figure 10-41: Place over the Open End



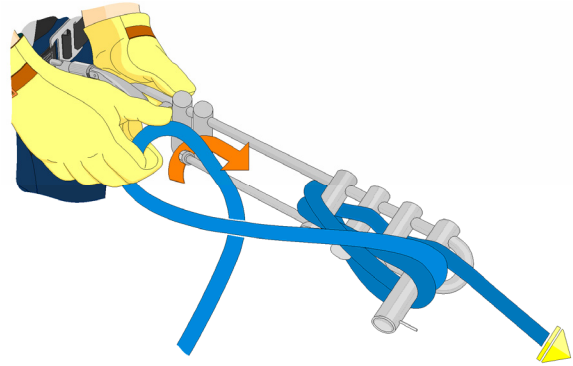
4. Place the half hitch over the open end of the brake bar rack and pull on the running end to tighten the half hitch.

Figure 10-42: Wrap the Running End



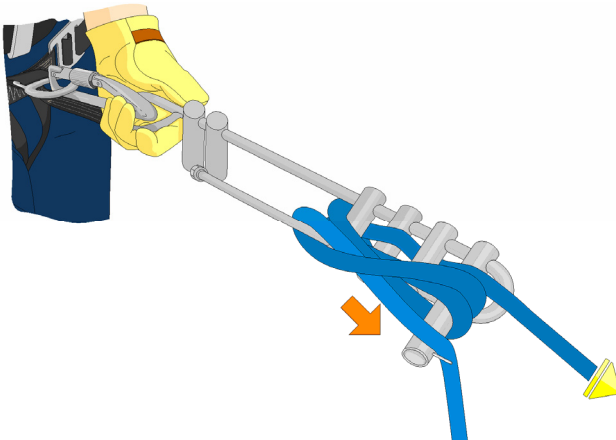
5. Wrap the running end around the tie-off bar a second time, but in the opposite direction.

Figure 10-43: Form another Half Hitch



6. Form another half hitch in the running end and place it over the open end of the rack.

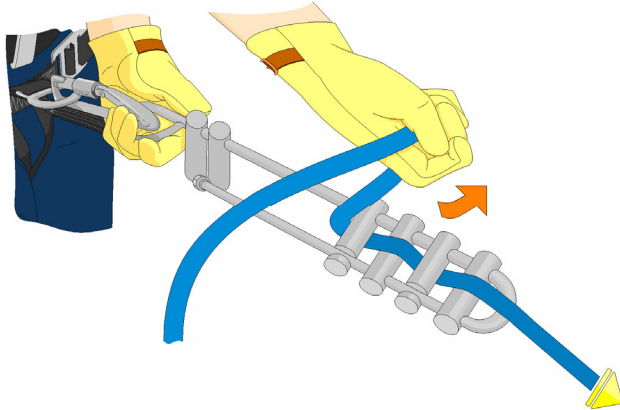
Figure 10-44: Pull the Running End to Tighten



7. Pull the running end to tighten second half hitch and place over the tie-off bar.

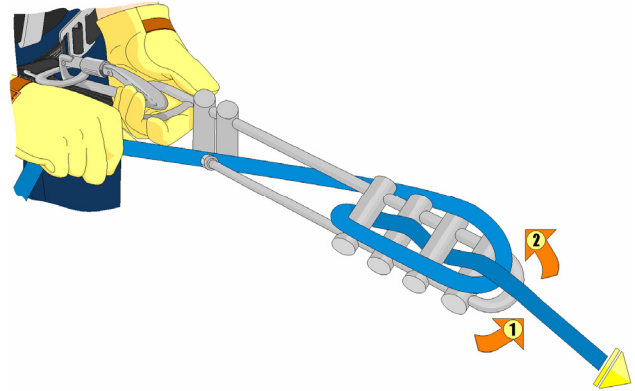
Brake Bar Rack without a Tie-off Bar

Figure 10-45: Position Hands



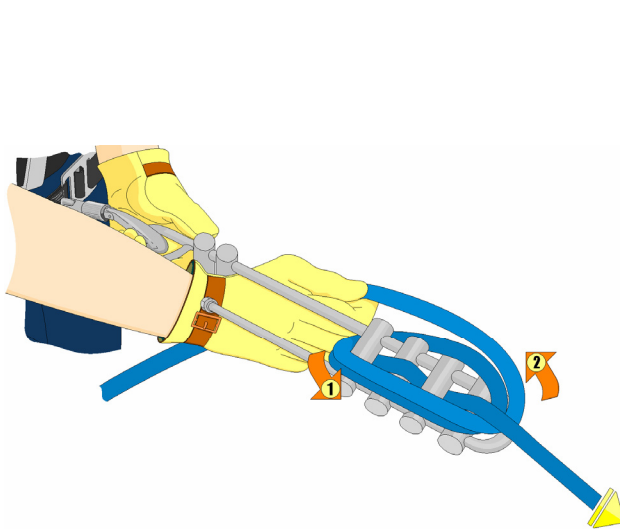
1. Position hands in the full brake position and rotate the rack towards the left.

Figure 10-46: Pull the Running End of the Rope



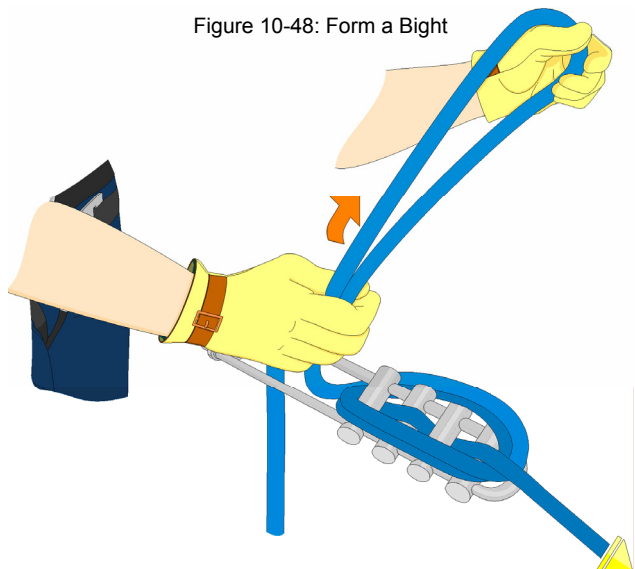
2. Use the brake hand to pull the running end of the rope across the top of the rack between the standing part of the line and the rack, continue wrapping the running end around the rack from top to bottom, come through the opening of the rack, and pull tight ending with the line above the first bar.

Figure 10-47: Make a Second Wrap



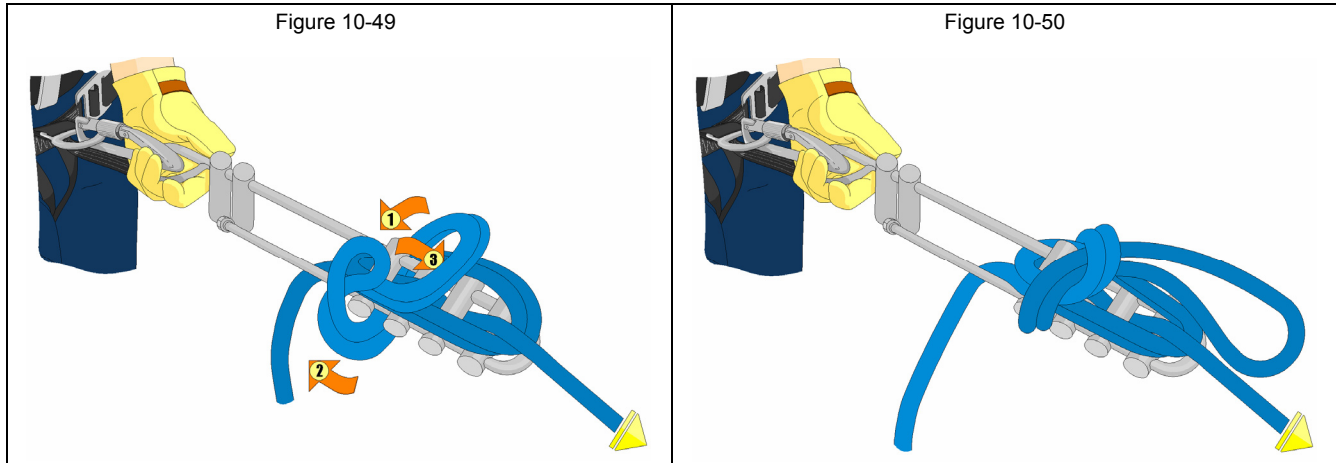
3. Make a second wrap by repeating Step 2.

Figure 10-48: Form a Bight



4. Form a bight in the running end.

5. Tie an overhand knot around the body of the rack. (Figures 10-49 and 10-50)



Ascending

Ascending is a very strenuous activity that is seldom used. On the occasions when it is required, it must be accomplished under controlled conditions or the outcome could be catastrophic. In most situations, it is better to bring rescuers up using a raising system from the top. In some instances, a rescuer needs to climb back to the point of origin after a rappel or for a self-rescue in the event of becoming jammed because of clothing or equipment caught in the rappel device during a rappel.

Equipment

One key to successful ascending, whether it is to return to the point of origin or for self-rescue, is to be equipped with the necessary equipment before the descent. The minimum equipment necessary for low angle ascending includes one (1) long prusik loop and one (1) extra carabiner.

Ascending for Positioning or Returning to Departure Point

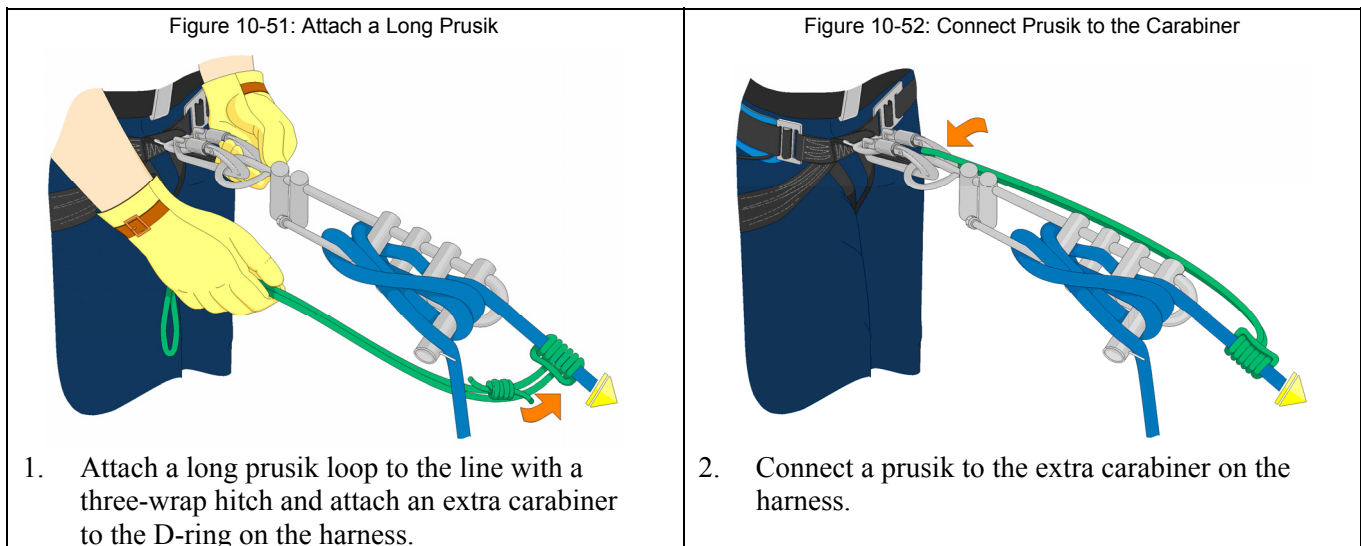


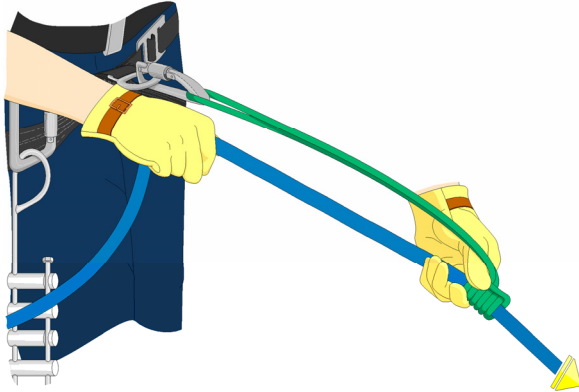
Figure 10-51: Attach a Long Prusik

Figure 10-52: Connect Prusik to the Carabiner

1. Attach a long prusik loop to the line with a three-wrap hitch and attach an extra carabiner to the D-ring on the harness.

2. Connect a prusik to the extra carabiner on the harness.

Figure 10-53: Slide Prusik Hitch up the Line



3. Slide the prusik hitch up the line with one hand while pulling the running end taut with the other hand. (Figure 10-53)
4. Simultaneously step forward.
5. Remember to keep the lower body perpendicular to the slope.
6. Disconnect the main line from the brake bar rack.
7. Repeat Steps 3-5 until the desired location has been reached.

How to Escape from a Jammed DCD

Topside Recovery Option

- Rescuer
 - Attaches a long prusik loop to the line in front of the DCD and connects it to the extra carabiner on the harness.
 - Slides prusik forward and leans back in order to tension/load the prusik.
- Topside Crew
 - Changes the fixed line over to a raising system and raises the rescuer to the top or a safe location to unjam the DCD.

Self-rescue Option

1. Attach a prusik loop to the line in front of the DCD and connect it to the harness with a second carabiner.
2. Ensure the Belayer is ready for raising belay.
3. Slide prusik hitch up the line with one hand while pulling the line taut with the other hand located between the DCD and the prusik hitch.
4. Simultaneously step forward.
5. Remember to keep lower body perpendicular to the slope.
6. Repeat these steps until there is enough slack to unjam the DCD.
7. Unjam the DCD.
8. Take slack out of the rappel line.
9. Lock the DCD.
10. Lean forward.
11. Remove the prusik.
12. Unlock the DCD.
13. Continue the rappel.

Chapter 11: Lower/Raise (Mechanical Advantage) Systems

Scope: This chapter serves as an introduction to lower/raise (mechanical advantage) systems.

Terminal Learning Objective (TLO): At the end of this chapter, the student will be aware the considerations when selecting the type of mechanical advantage system (MA) to be used in a raising operation.

Enabling Learning Objectives (ELO):

1. Describe rope rescue lowering and raising systems
2. Demonstrate how to convert a lowering system to a raising system with a 3:1 inline - rpm
3. Demonstrate how to operate a lowering system
4. Demonstrate how to convert a lowering system to a raising system with a 5:1 inline – rpm and a 3:1 or 5:1 inline with directional pulley
5. Demonstrate how to construct a 3:1 and 5:1 mechanical advantage system
6. Demonstrate how to construct a 3:1 and 5:1 pig rig
7. Demonstrate how to convert a lowering system to a raising system with a 3:1 and 5:1 pig rig

Rescue operations in low angle rope rescue, in terms of victim extrication, are primarily a lower/raise function. The tools and staffing positions to complete the lowering operations can be completed off the main line component of an RPM system.

This may not be the case with raising operations. Equipment may be required from the mechanical advantage component and an additional line may be required as well.

Therefore, the rescuer has a few options to consider when selecting the type of mechanical advantage system (MA) to be used in a raising operation. This chapter will show the following considerations for MA systems:

- The inline MA system.
- The inline MA system with a change of direction.
- The piggyback system.
- Straight pull.
- Apparatus positioning.

Key Points Regarding Lower/Raise Operations

- Basic lowering operations and inline MAs can be accomplished off the main line component and be supervised by the Rope Group Supervisor (RGS). A more detailed explanation of job titles and functions is in Chapter 13.
- MA systems with a directional change require additional equipment and staffing. This includes both in-line and piggyback systems.
- A Haul Team Leader will direct the construction of the MA system, command and control the haul team, and report to the RGS. This is a key management position and requires a person with strong leadership skills and a high technical knowledge base of rope rescue operations.
- Apparatus positioning is also very important. Proper positioning of the apparatus will ensure a safe and adequate working area for personnel and maximize the effectiveness of the MA system used.
- As the name denotes, this is the primary line in any rope system. The main line will be loaded during rappel and lowering and/or raising operations. The main line may also have the additional duty of a haul line in some mechanical advantage systems.

Lowering Line Systems

- All or part may be prerigged and bagged.

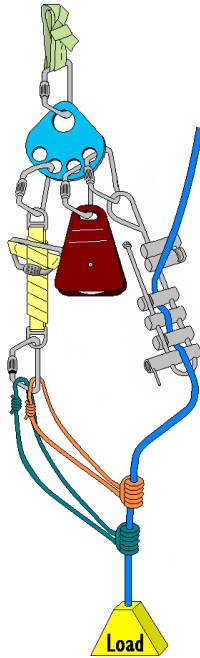


Figure 11-1: With Brake Bar Rack

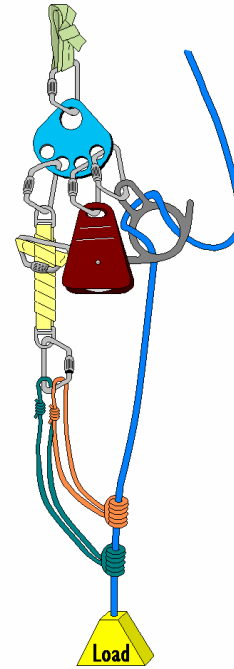


Figure 11-2: With Eight Plate

System Staffing

- Lowering line tender(s) **required**.
 - Tends descent control device (figure eight plate or brake bar rack).
- Lowering line brake **optional**.
 - If used, a brake tender is **required** to tend the tandem prusiks.

System Operation

- Brake bar rack – one- or two-person load.
 - One tender - adjusts bars as required.
- Figure eight plate – one-person load.
 - One tender – adjusts attachment as needed.
- Figure eight plate – two-person load.
 - Two tenders – adjust attachment as needed.
- Tandem prusik brake.
 - May be removed (staffing or operational considerations).
 - Staffed by main line brake tender when used.

Raising (MA) Systems

These systems are typically utilized after lowering operations are complete. They are either constructed at the scene as part of the main line with component pieces (inline system) or are prepackaged in a separate rope bag and attached to the main line (piggyback system). This chapter deals with the following variations of the haul/MA systems:

- ❶ 3:1 and 5:1 inline MA systems.
- ❷ 3:1 and 5:1 MA systems with a directional change pulley.
- ❸ 3:1 and 5:1 piggyback systems.
- ❹ Straight pull system.

System Staffing¹

- Main Line Brake Tender.
- Haul Team.

Key Points Regarding Raising Operations²

Prusik Brake(s)

The prusik brake(s) shown in this chapter are not ratchet cams; they are not configured to self tend. The distance is too great between the pulley and the prusik. This distance creates an excessive amount of slack in the main line if released or set. The brake(s) *must*, therefore, be tended.

Haul Team

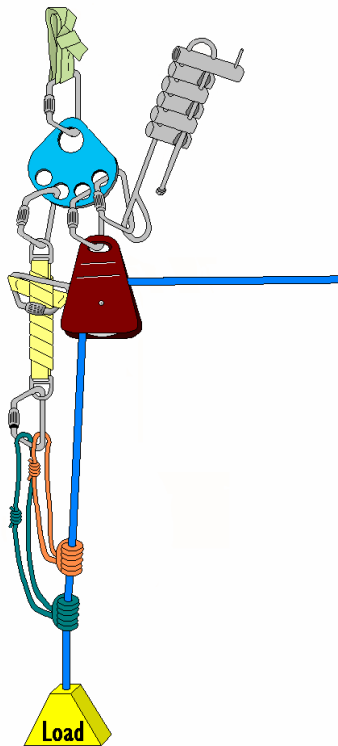
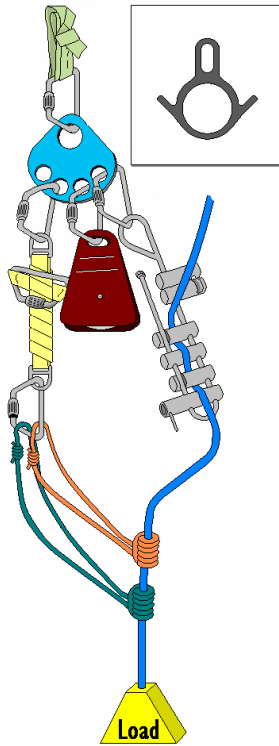
The Haul Team will typically grasp the line and walk in a controlled manner to apply force to the system. In situations of limited hauling space, the team will haul using the hand-over-hand method.

Lower to Raise Conversion: 3:1 Inline – RPM

- 1) Tie off the DCD as shown in Chapter 10.
 - If prusiks were not attached to the main line during lowering operations.
 - Not needed if litter team/rescuers are on a safe level platform.
 - Not needed if the lowering line tender holds tension as prusiks are attached.
- 2) Attach prusik(s) to the line if not previously attached during the lowering operation.
 - One prusik is proven adequate as a brake to the main line.
 - It is not necessary to attach the second prusik to the main line, but it is acceptable to do so.

¹ Additional positions are described in Chapter 13: Scene Organization and Management.

² Additional key points are described in Chapter 13: Scene Organization and Management.



Main line
brake may
be one or
two prusiks.

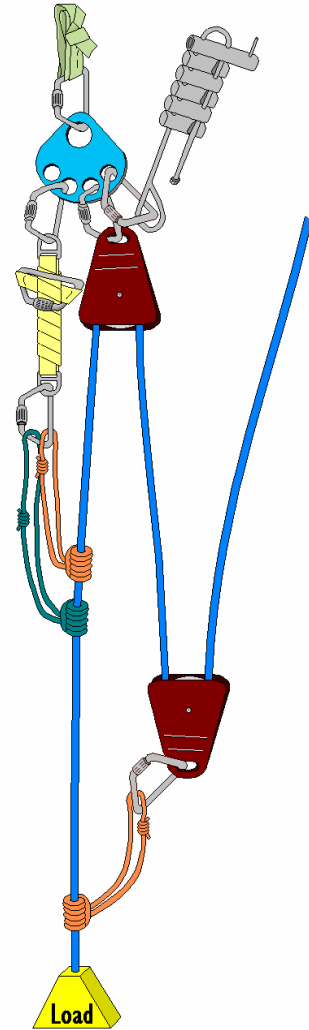


Figure 11-3

Figure 11-4

Figure 11-5

- 3) Set the prusik(s) brake.
- 4) Remove the line from the DCD.
- 5) Attach haul prusik (short) to line on load side of prusik(s).
- 6) Install haul line in mechanical advantage pulley.
- 7) Connect mechanical advantage pulley to haul prusik with carabiner.

Lower to Raise Conversion: 5:1 Inline – RPM

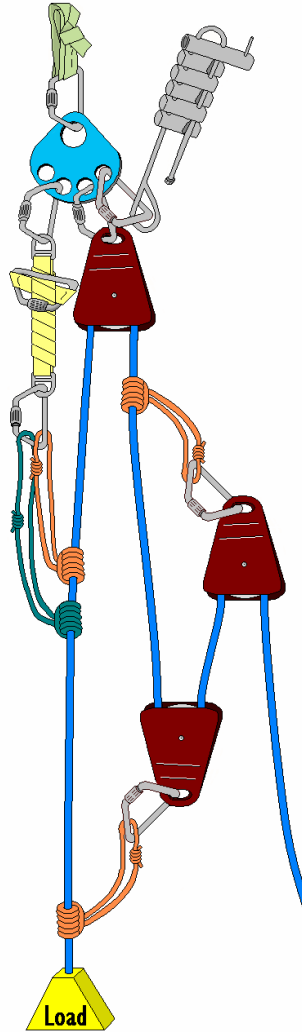


Figure 11-6

- 1) Attach haul prusik (short) to line on haul side of prusik minding pulley on RPM.
- 2) Install haul line in second mechanical advantage pulley.
- 3) Connect second mechanical advantage pulley to haul prusik with carabiner.

Lower to Raise Conversions

Once lowering operations are completed, the rescuer and victims most often must be pulled back up the incline to a safe area. This is accomplished by utilizing mechanical advantage or haul systems. In order to accomplish this, the rescuer must know how to convert a lowering system to a raising system. This initial conversion process will be the same for all mechanical advantage systems in this course.

3:1 or 5:1 Inline Mechanical Advantage System

If the distance between the main line anchor and edge is adequate, an inline mechanical advantage system will be used. Adequate distance will provide the hauling team a safe area to work inline toward the incident. This distance must also be long enough to minimize the number of resets necessary to complete raising operations. Keep in mind how much rope will be used to reach the victim(s); this will determine your maximum set back.

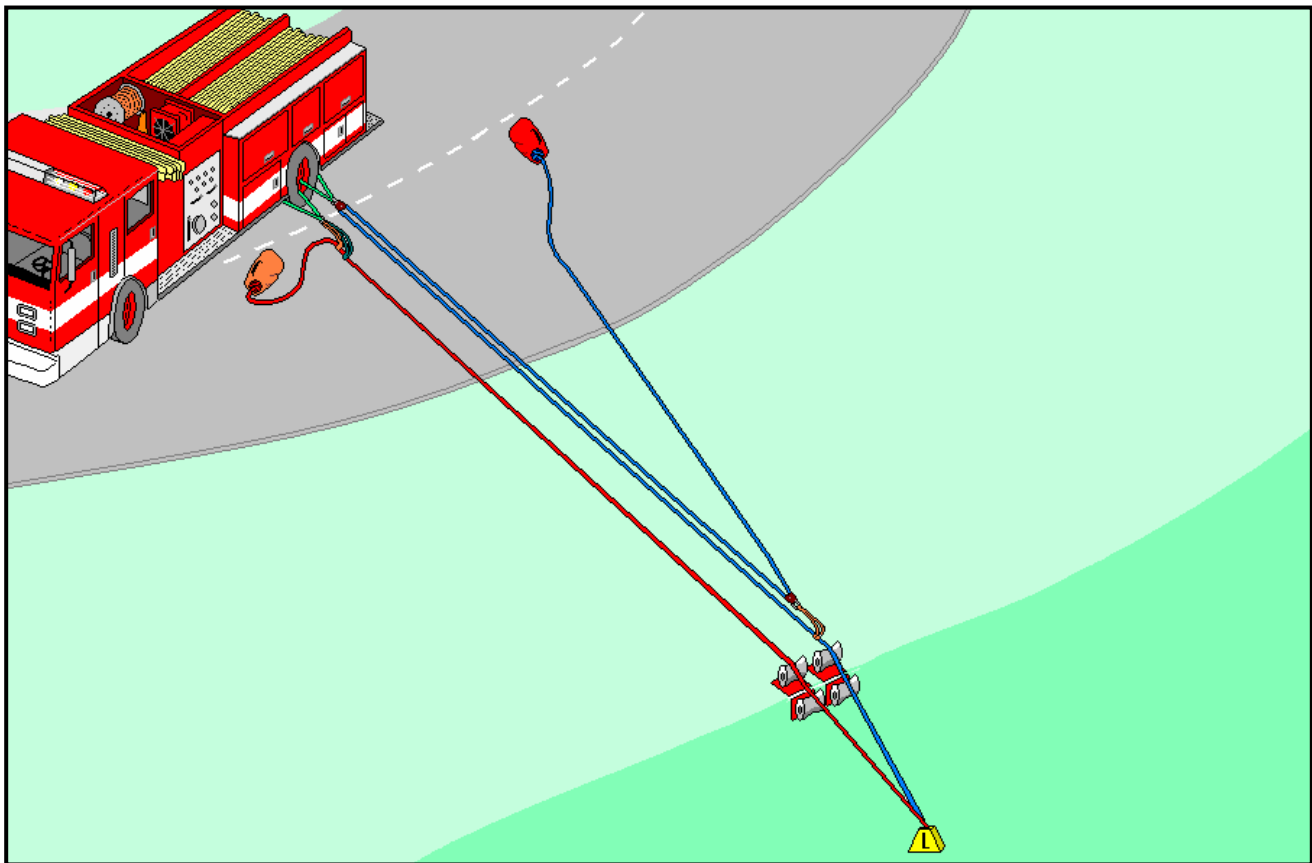


Figure 11-7: 3:1 or 5:1 Mechanical Advantage Inline System Layout

3:1 or 5:1 Inline with Directional Pulley

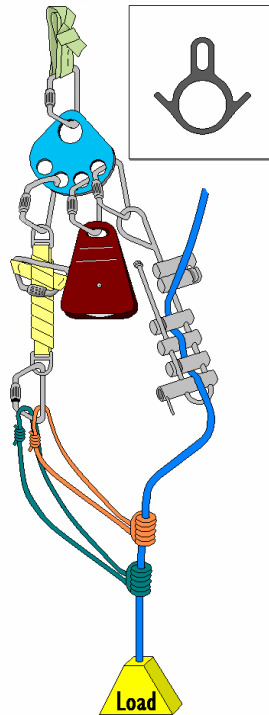


Figure 11-8: Lower with Load

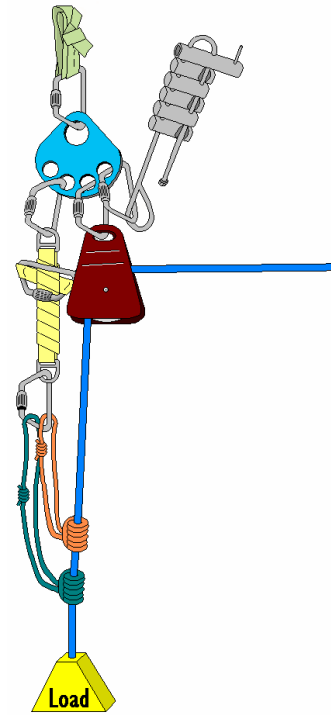


Figure 11-9: Mainline Brake with Load

- 1) Tie off the DCD as shown in Chapter 10.
 - If prusiks were not attached to the main line during lowering operations.
 - Not needed if litter team/rescuers are on a safe level platform.
 - Not needed if the lowering line tender holds tension as prusiks are attached.
- 2) Attach prusik(s) to the line if not previously attached during the lowering operation.
 - One prusik is proven adequate as a brake to the main line.
 - It is not necessary to attach the second prusik to the main line, but acceptable to do so.
- 3) Set the prusik(s) brake.
- 4) Remove the line from the DCD.
- 5) Install the line through the prusik minding pulley.
- 6) Place the line toward the secondary anchor (second apparatus).
- 7) Attach sling to secondary anchor. The secondary anchor is often a vehicle or picket system positioned along the road or trailhead at an angle to the mainline RPM as shown. Always maximize the distance between these two anchors in order to reduce the number of resets during hauling [raising] operations. In a **3:1** system, that distance will be one-half the length of the remaining rescue line. In a **5:1** operation, that distance will be one-third.

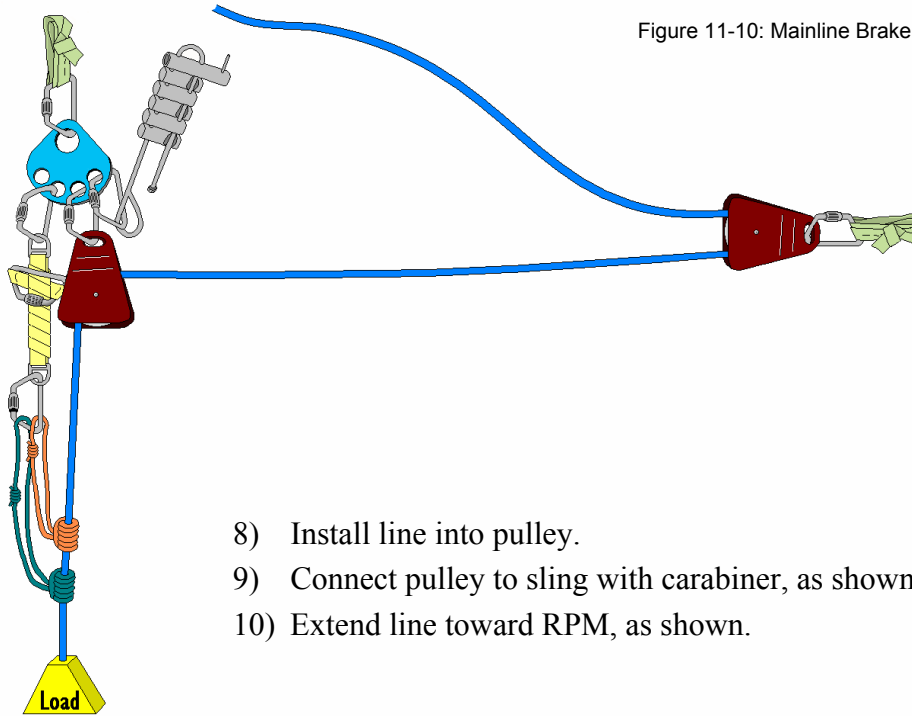


Figure 11-10: Mainline Brake

- 8) Install line into pulley.
- 9) Connect pulley to sling with carabiner, as shown.
- 10) Extend line toward RPM, as shown.

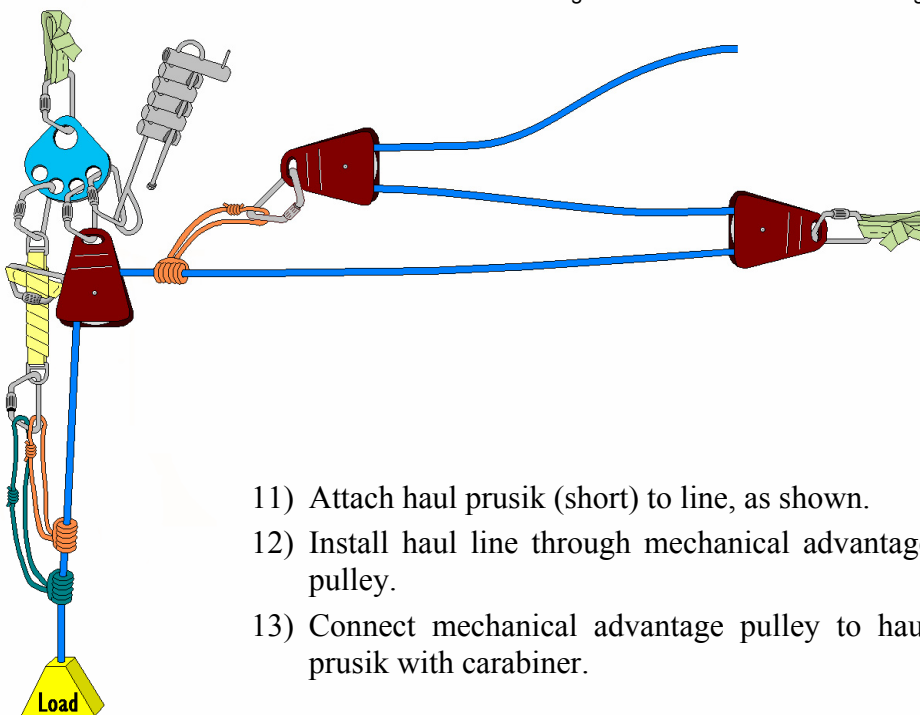


Figure 11-11: 3:1 Mechanical Advantage

- 11) Attach haul prusik (short) to line, as shown.
- 12) Install haul line through mechanical advantage pulley.
- 13) Connect mechanical advantage pulley to haul prusik with carabiner.

Often at low angle rope rescue incidents, there is inadequate working area for an inline mechanical advantage system. In these situations, a directional change pulley is used at the main line RPM to change the direction of the main line to a secondary anchor (often a second engine). This apparatus is located a good working distance (approximately one-half the length of the unused rope in the bag for a 3:1 mechanical advantage system or one-third the length of unused rope in the bag for a 5:1 mechanical advantage system) from the main anchor and placed parallel to the roadway or trail. When an apparatus is staged in this position, it can also provide a safe working area for the haul team.

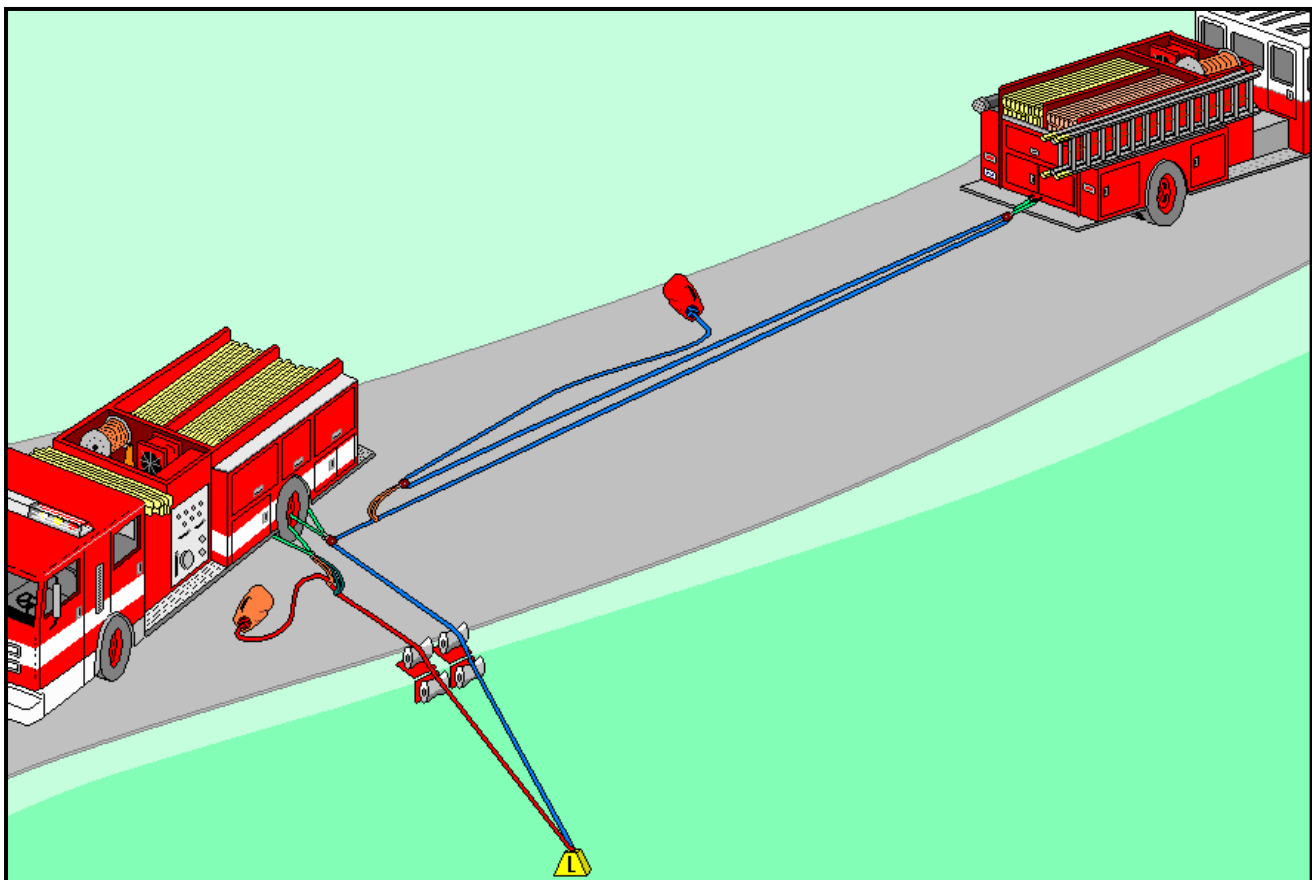


Figure 11-12: 3:1 Mechanical Advantage Directional Change System Layout

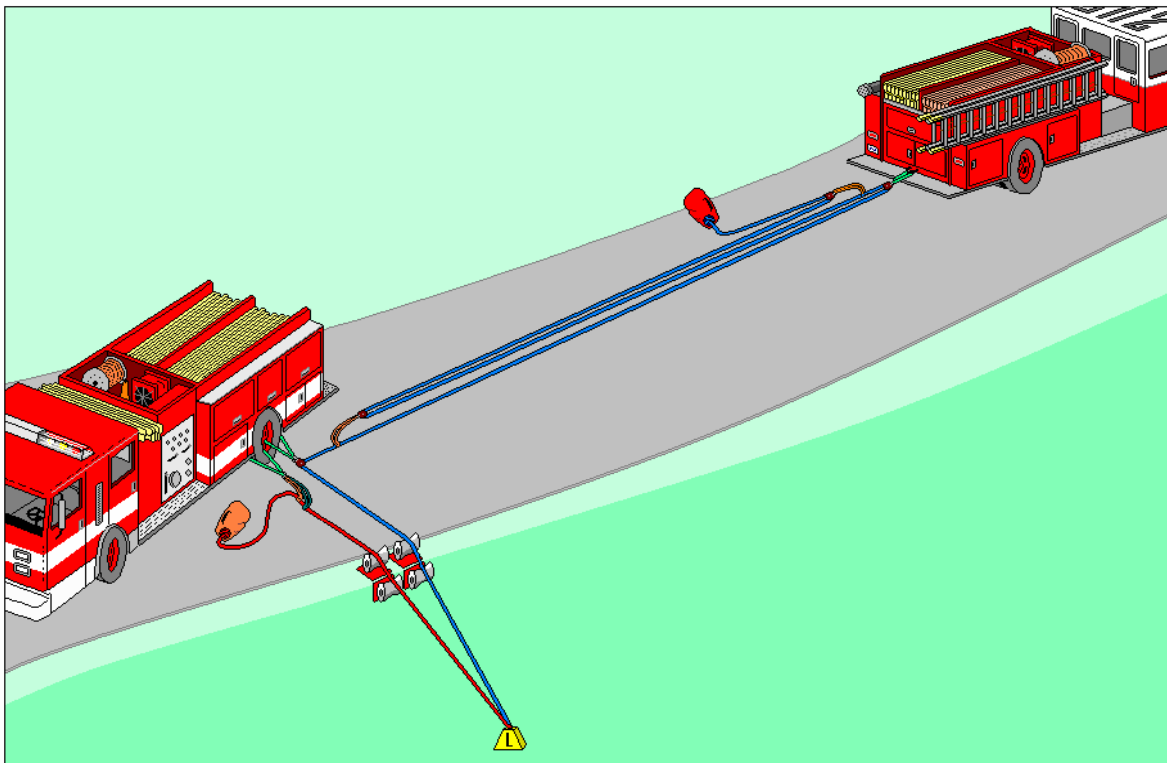
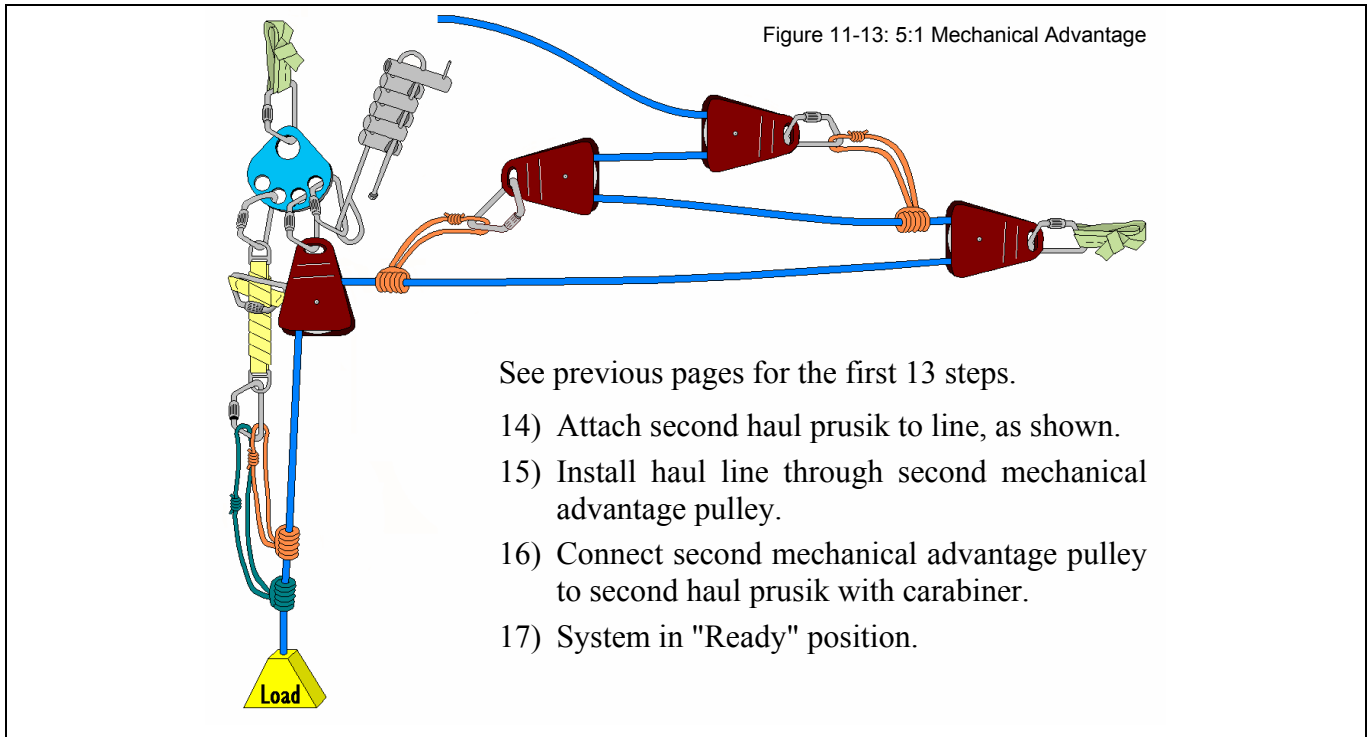


Figure 11-14: 5:1 Mechanical Advantage Directional Change System Layout

Key Points for Apparatus Placement

- The set back of the apparatus and/or anchor will be determined by your working area, type of mechanical advantage used, and the amount of line used.
 - Consider the condition of the edge. Will it support the apparatus?
 - Consider your minimum working space. Is it enough room for the litter, RPM, and their operation?
 - Consider your maximum working space. It is dependent on the rope length and available area.
- The angle that the apparatus is positioned will determine how raising operations are set up.
 - Position the apparatus with enough angle to provide clear access to the secondary anchor/apparatus.
 - The angle is determined by the location and lay out of the apparatus.

Piggyback Systems

Introduction

In long lowering operations, most of the main line can be used in the primary lower. This will not leave enough line to construct an inline mechanical advantage system. In these situations, a "piggyback" or "pig rig" mechanical advantage system is used. In this course, two options will be presented: a 3:1 and a 5:1 piggyback system. As with inline systems, the 5:1 will build off the 3:1 rigging.

Key Points

- A piggyback system adds another line to the main (lowering) line, much as a block and tackle does. This added line will provide the mechanical advantage needed for raising operations and is often referred to as the haul line, MA line, or pig line.
- The pig rig concept allows the first-in companies to fully extend the first two lines (belay/safety and main) to the incident.
 - It also allows a second-in company to construct, extend, anchor, attach, and operate the mechanical advantage system.
- Many teams carry a preassembled pig rig in a third rope bag. This can be quickly extended and attached to the main line, reducing set-up time for the raising system.

Pig Rig Construction: 3:1

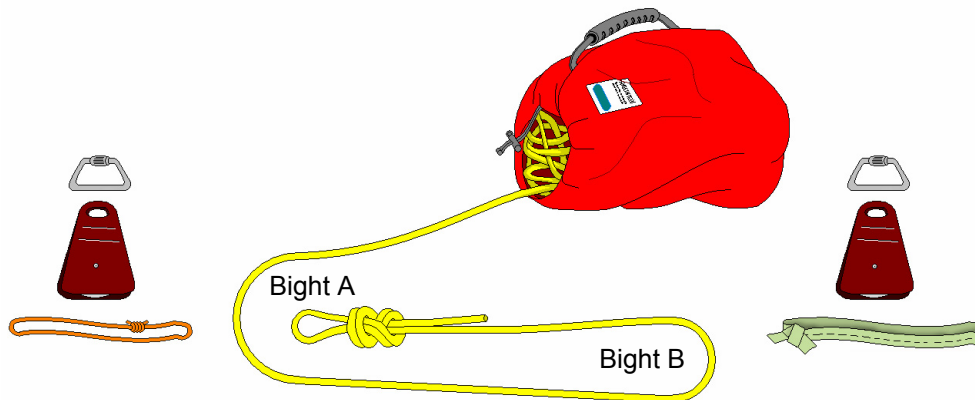


Figure 11-15: How to Construct a 3:1 Pig Rig

- 1) Tie a figure eight on a bight with a 4" loop in the end of the pig rig line.
- 2) Place rope on the ground, forming two bights as shown above.
- 3) Place bight "B" into pulley and connect a carabiner to this pulley.
- 4) Connect an anchor sling (5'-20') to this carabiner.
- 5) Place bight "A" into pulley and connect a carabiner to this pulley.
- 6) Secure figure eight on a bight into this carabiner on top of the pulley.
- 7) Connect the short prusik to this carabiner

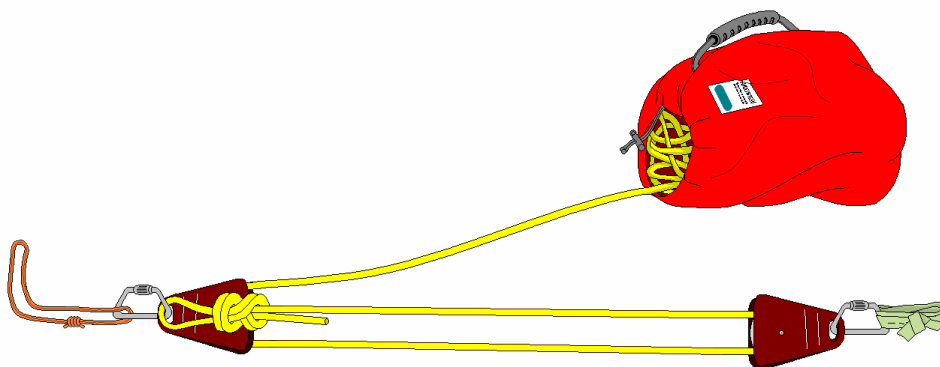


Figure 11-16: Assembled 3:1 Pig Rig

Pig Rig Construction: 5:1

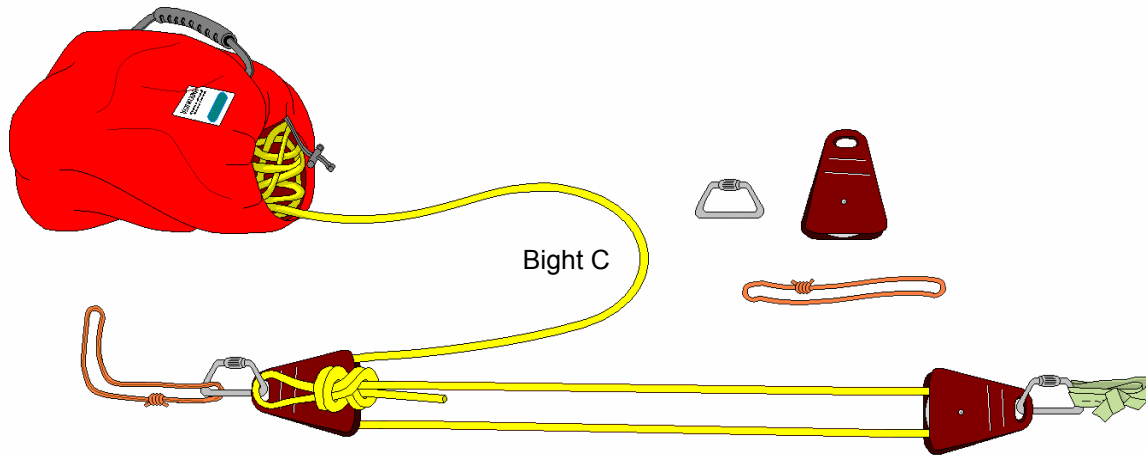


Figure 11-17: How to Construct a 5:1 Pig Rig Starting from a 3:1 Pig Rig

- 1) Place the rope on the ground to form bight "C."
- 2) Place bight "C" inside the pulley and connect a carabiner to this pulley.
- 3) Attach a short prusik to the line at the pulley on bight "B" using a three-wrap prusik hitch.
- 4) Connect the prusik loop to the bight "C" pulley with the carabiner.

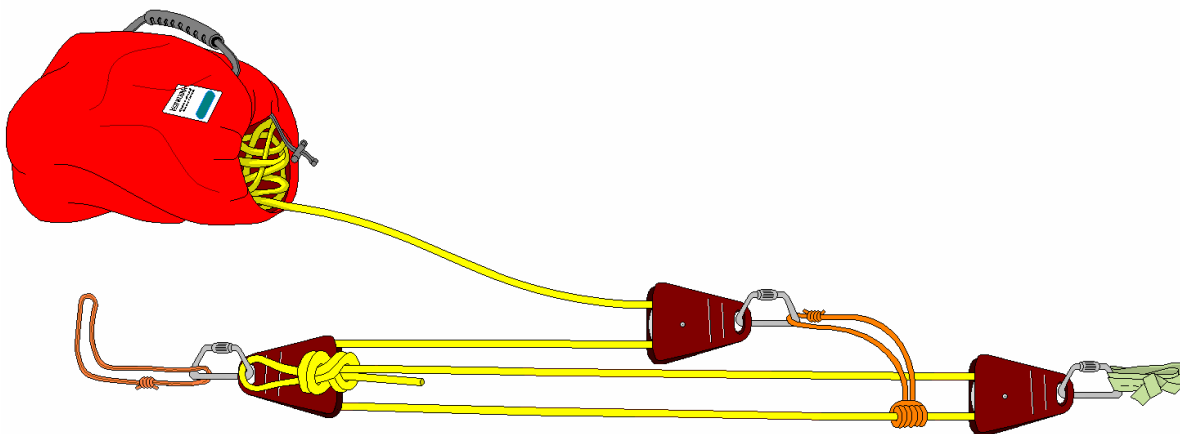


Figure 11-18: Assembled 5:1 Pig Rig

Lower to Raise Conversion: 3:1 Pig Rig

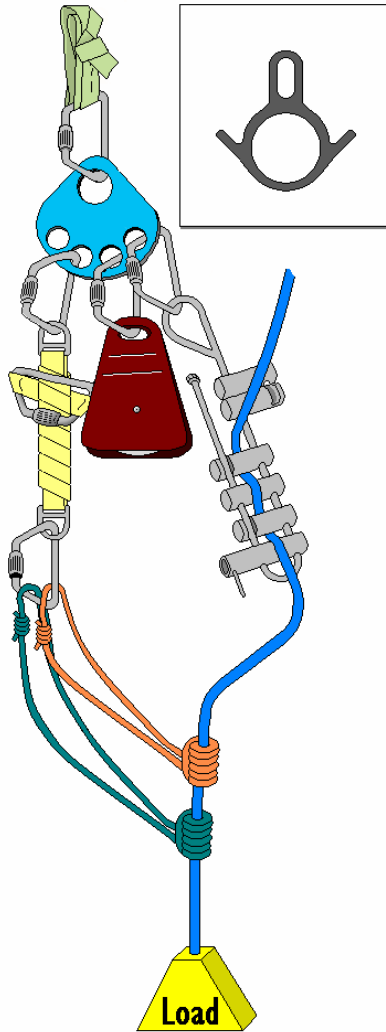


Figure 11-19: Lower with Load

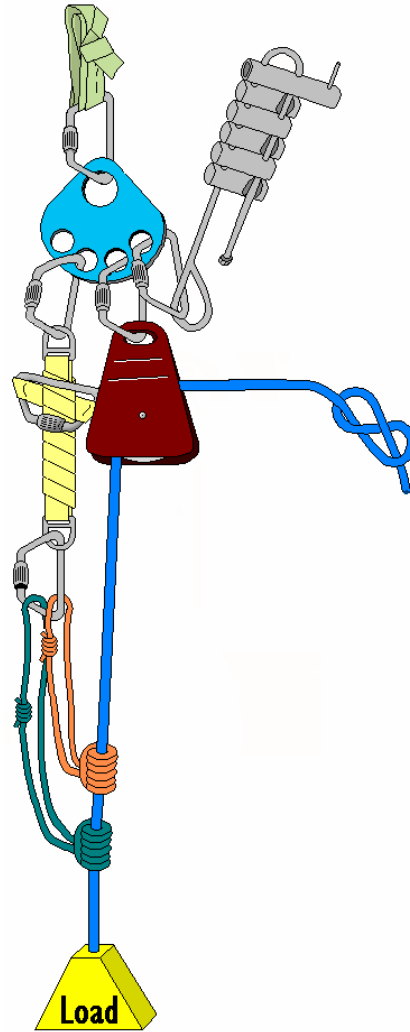


Figure 11-20: Mainline Brake with Load

- 1) Tie off the DCD as shown in Chapter 10.
 - If prusiks were not attached to the main line during lowering operations.
 - Not needed if litter team/rescuers are on a safe level platform.
 - Not needed if the lowering line tender holds tension as prusiks are attached.
- 2) Attach prusik(s) to the line if not previously attached during the lowering operation.
 - One prusik is proven adequate as a brake to the main line.
 - It is not necessary to attach the second prusik to the main line, but acceptable to do so.
- 3) Set the prusik(s) brake.

- 4) Remove the line from the DCD.
- 5) Install line through prusik minding pulley.
- 6) Place line toward secondary anchor (second apparatus).
- 7) Construct the 3:1 pig rig or lay out preassembled pig rig.

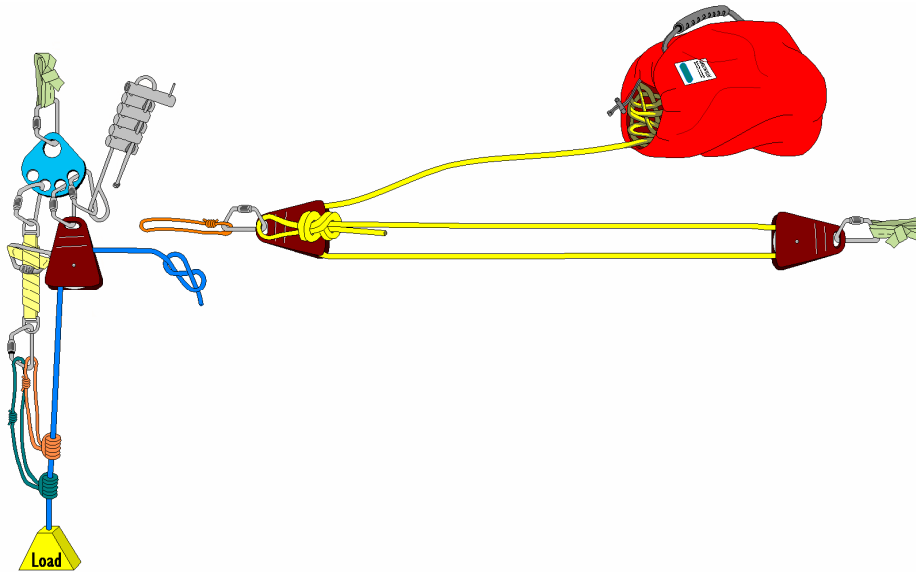


Figure 11-21: Construct 3:1 Pig Rig

- 8) Extend the 3:1 pig rig from the secondary anchor to the main line anchor.

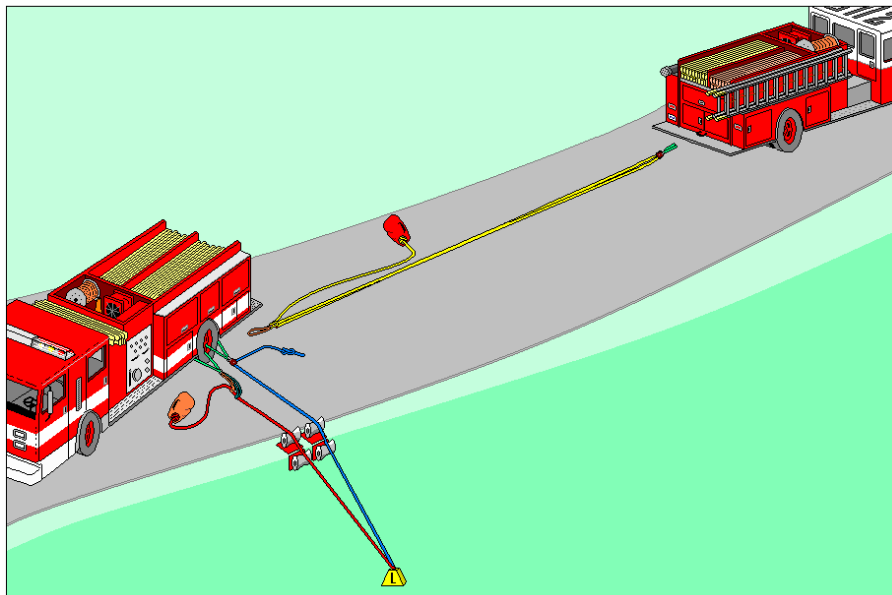


Figure 11-22: Extend 3:1 Pig Rig

- 9) Anchor the 3:1 pig rig using an anchor sling to attach to the secondary anchor.
The secondary anchor is often a vehicle or picket system positioned along the road or trailhead. Always maximize the distance between these two anchors in order to reduce the number of resets during hauling [raising] operations. In a 3:1 system, that distance will be just under one-half the length of the haul line.

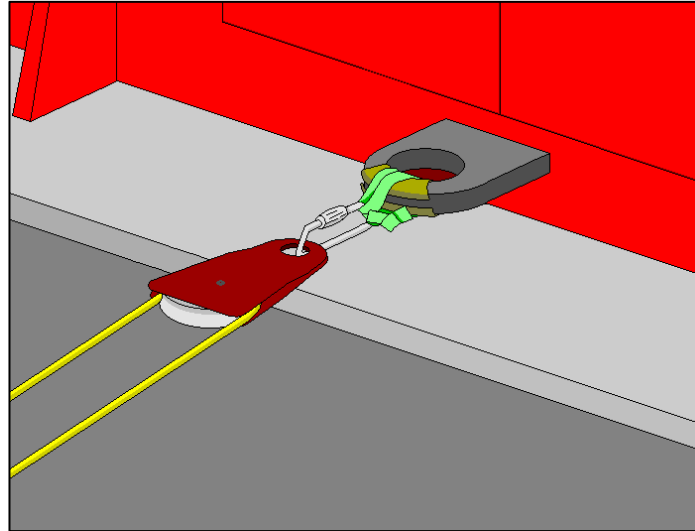


Figure 11-23: Anchor 3:1 Pig Rig

- 10) Attach the 3:1 pig rig to the main line using the short prusik already attached to the pig rig.

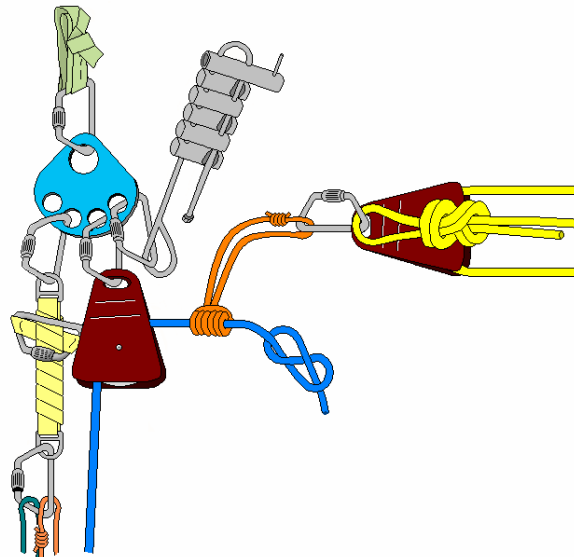


Figure 11-24: Attach 3:1 Pig Rig

11) System in "Ready" position.

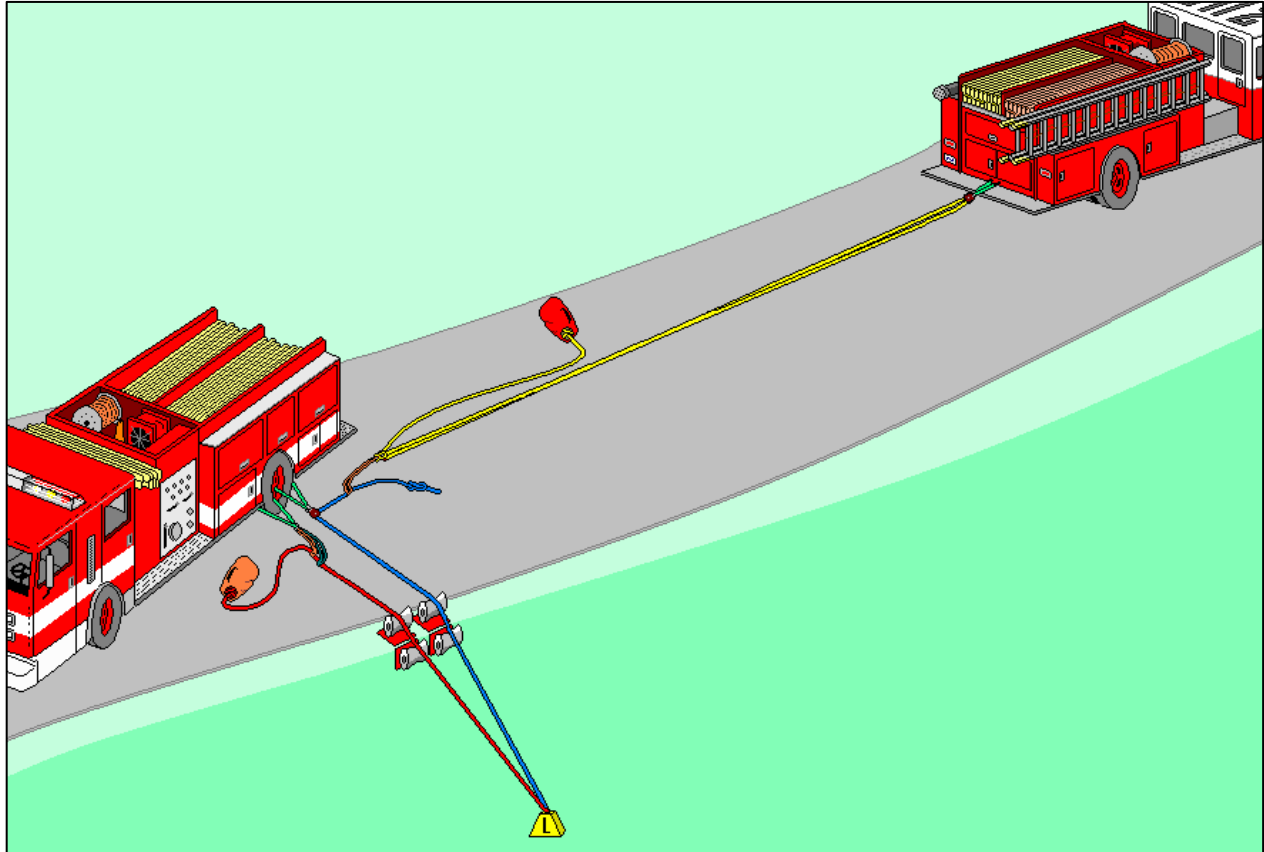


Figure 11-25: 3:1 Pig Rig with Directional Change System Layout

Key Points for Apparatus Placement

- The set back of the apparatus and/or anchor will be determined by your working area, the type of mechanical advantage used, and the amount of line used.
 - Consider the condition of the edge. Will it support the apparatus?
 - Consider your minimum working space. Is it enough room for the litter, RPM, and their operation?
 - Consider your maximum working space. It is dependent on the rope length and available area.
- The angle that the apparatus is positioned will determine how raising operations are set up.
 - Position the apparatus with enough angle to provide clear access to the secondary anchor/apparatus.
 - The angle is determined by the location and lay out of the apparatus.

Lower to Raise Conversion: 5:1 Pig Rig

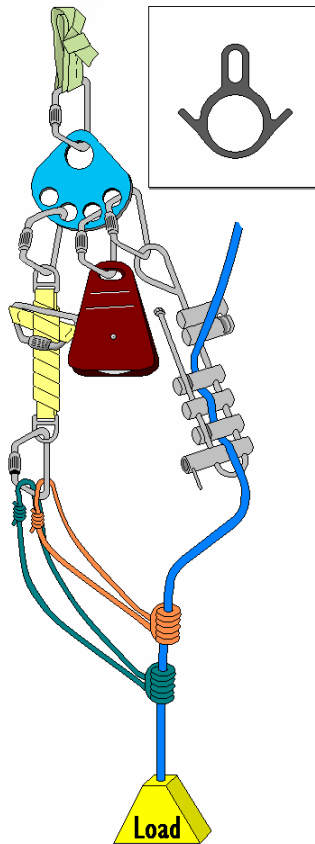


Figure 11-26: Lower with Load

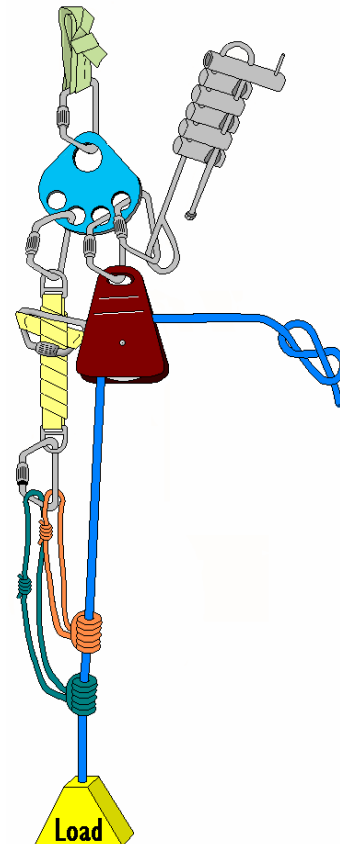


Figure 11-27: Mainline Brake with Load

- 1) Tie off the DCD as shown in Chapter 10.
 - If prusiks were not attached to the main line during lowering operations.
 - Not needed if litter team/rescuers are on a safe level platform.
 - Not needed if the lowering line tender holds tension as prusiks are attached.
- 2) Attach prusik(s) to the line if not previously attached during the lowering operation.
 - One prusik is proven adequate as a brake to the main line.
 - It is not necessary to attach the second prusik to the main line, but is acceptable to do so.
- 3) Set the prusik(s) brake.
- 4) Remove the line from the DCD.
- 5) Install line through prusik minding pulley.
- 6) Place line toward secondary anchor (second apparatus).

- 7) Construct the 5:1 pig rig or lay out preassembled pig rig.

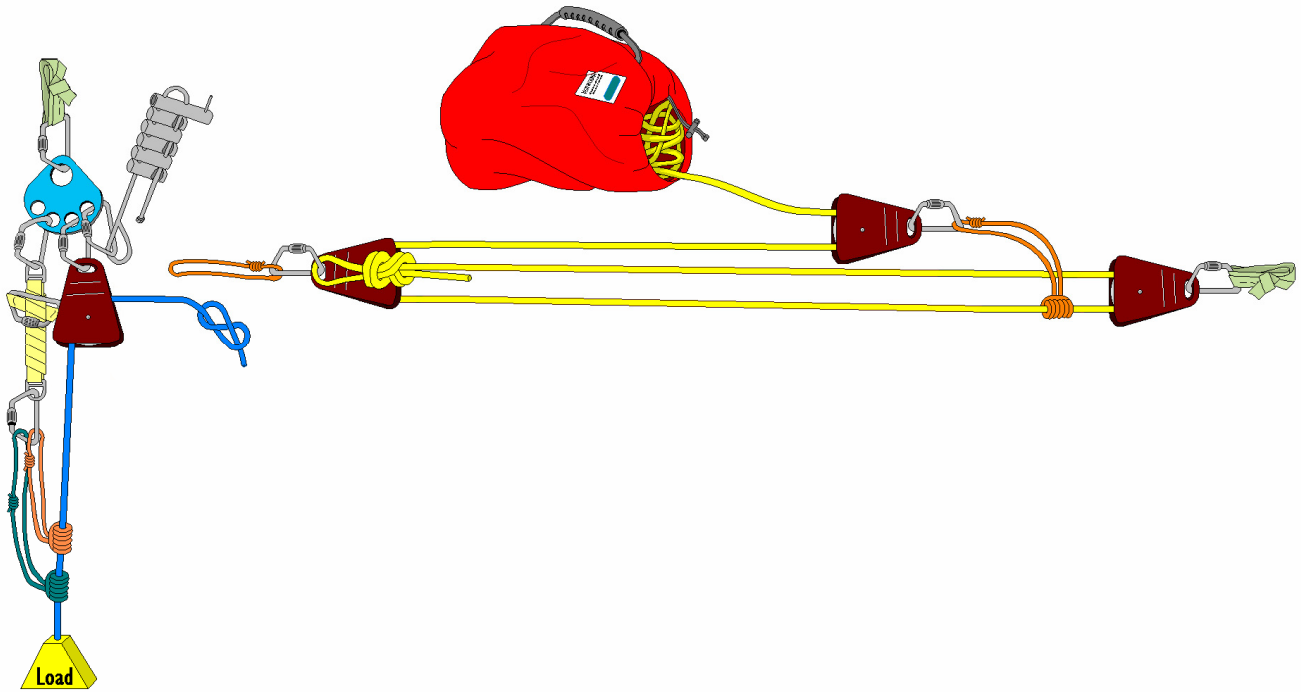


Figure 11-28: Construct 5:1 Pig Rig

- 8) Extend the 5:1 pig rig from the secondary anchor to the main line anchor.

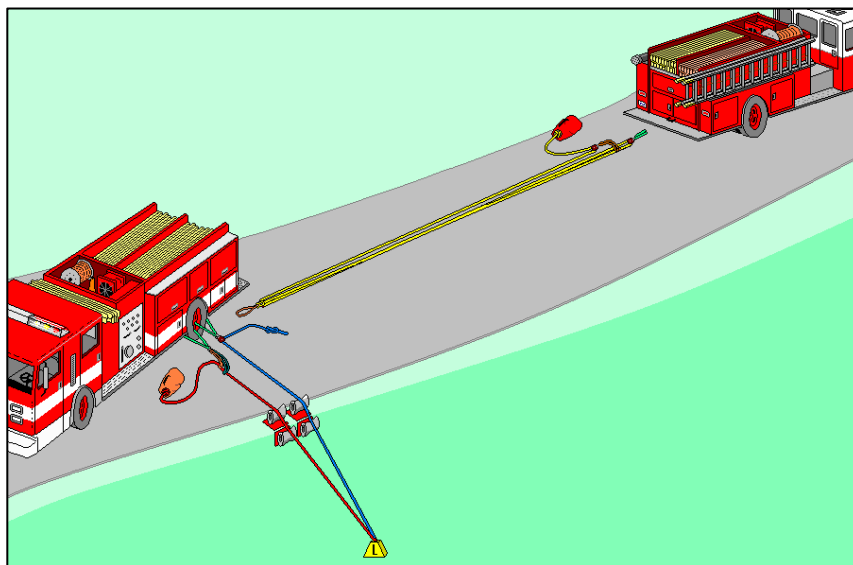


Figure 11-29: Extend 5:1 Pig Rig

The secondary anchor is often a vehicle or picket system positioned along the road or trailhead. Always maximize the distance between these two anchors in order to reduce the number of resets during hauling [raising] operations. In a 5:1 system, that distance will be approximately one-third the length of the haul line.

- 9) Anchor the 5:1 pig rig using an anchor sling to attach to the secondary anchor.

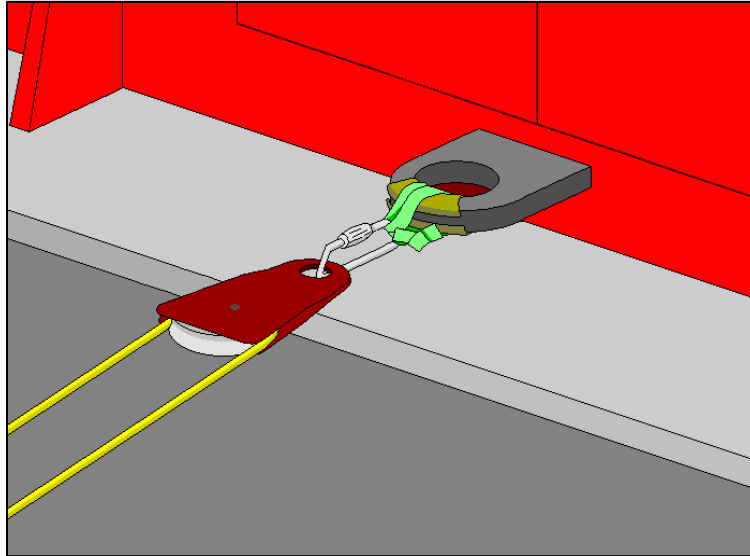


Figure 11-30: Anchor 5:1 Pig Rig

- 10) Attach the 5:1 pig rig to the main line using the short prusik already attached to the pig rig.

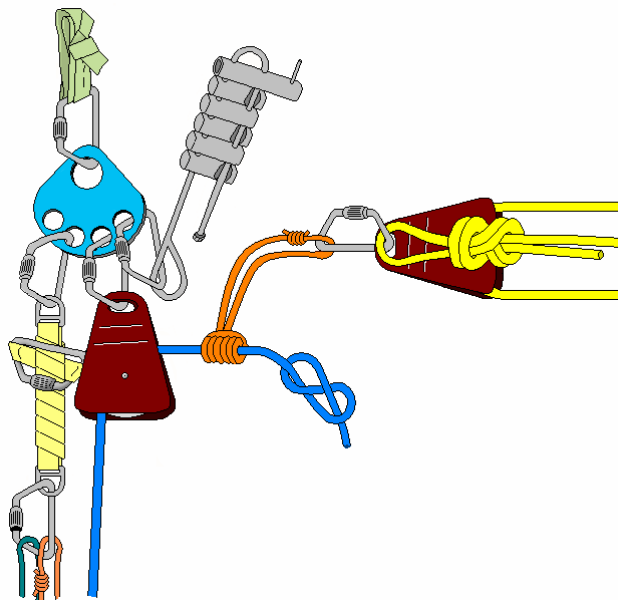


Figure 11-31: Attach 5:1 Pig Rig

11) System in "Ready" position.

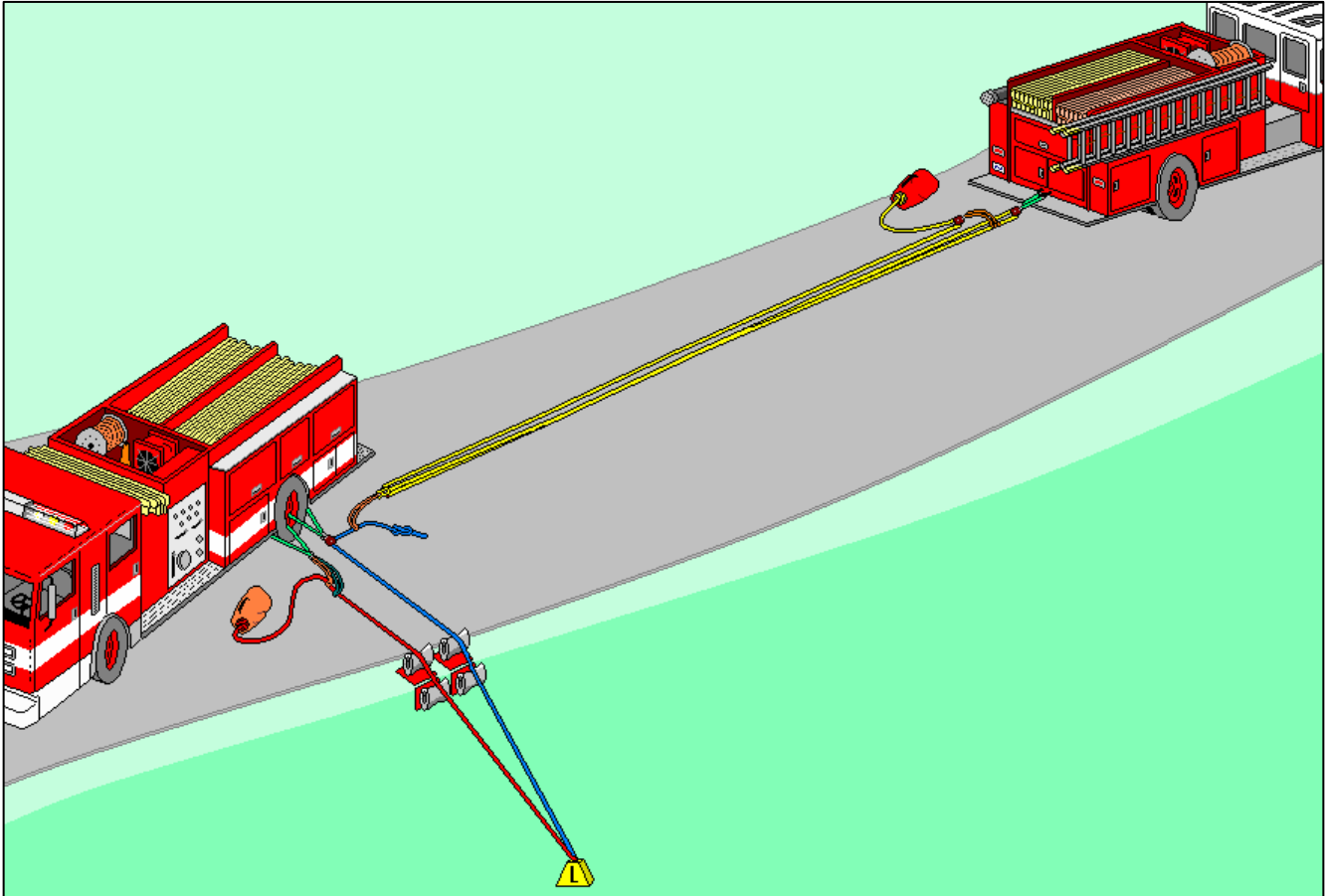


Figure 11-32: 5:1 Pig Rig with Directional Change System Layout

Straight Pull

Occasionally, the situation may arise where responders have adequate staffing but limited equipment with which to construct a mechanical advantage system. In these cases, an option to consider is the straight pull.

The formula to calculate a straight pull or 1:1 mechanical advantage system is that each rescuer hauling on the line can pull approximately 100 pounds of load.

Environmental conditions such as terrain and weather may affect the rescuers grip and footing. Thus, a 400-pound load to be lifted would require a minimum of 4 rescuers on the haul line. In a low angle haul situation, the amount of load may be increased or reduced by the following factors: 1) the angle of slope and 2) the amount weight being transferred from the litter tenders to the ground.

In low angle applications of the straight pull, two lines are used. The safety line uses a brake system, such as tandem prusiks, connected to a suitable anchor. The main line typically runs through a change

of direction pulley or simply a carabiner, which is also connected to a suitable anchor. The pulley is preferable due to the reduction in friction on the rope, but in the absence of a pulley, a carabiner may be used. A steel carabiner would be preferable to an aluminum carabiner because steel is stronger and produces less friction than aluminum. No other equipment is necessary on the main line.

Key Points for Apparatus Placement

- ❑ The set back of the apparatus and/or anchor will be determined by your working area, type of mechanical advantage used, and the amount of line used.
 - Consider the condition of the edge. Will it support the apparatus?
 - Consider your minimum working space. Is it enough room for the litter, RPM, and their operation?
 - Consider your maximum working space. It is dependent on the rope length and available area.
- ❑ The angle at which the apparatus is positioned will determine how raising operations are set up.

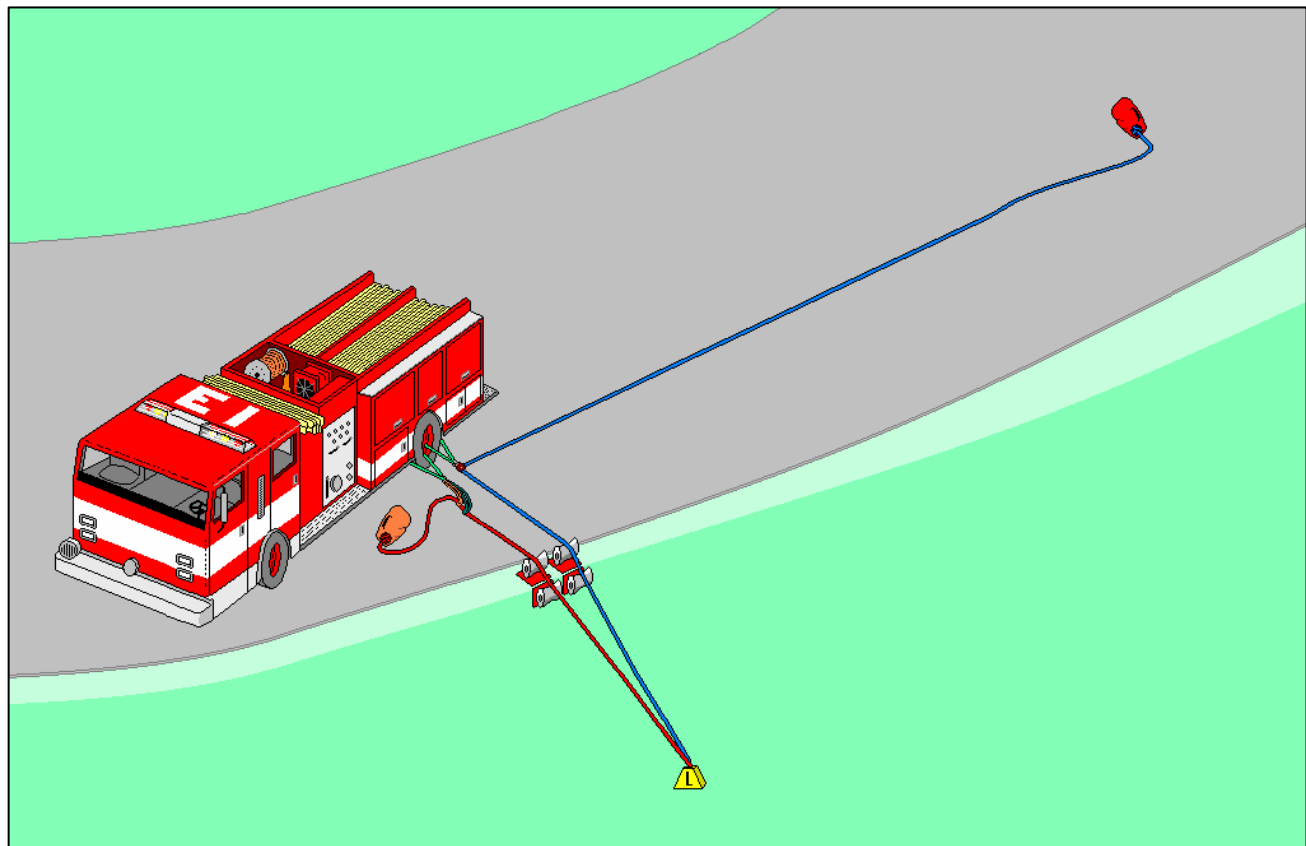


Figure 11-33 Straight Pull