

General Ropes Lesson Two Anchors and Mechanical Advantage Systems

DOMAIN: PSYCHOMOTOR

LEVEL OF LEARNING: KNOWLEDGE / APPLICATION

MATERIALS

IFSTA 7th Edition Fire Service Search and Rescue; IFSTA 5th edition Essentials of Firefighting. Laptop computer, multimedia projector, and whiteboard or flipchart, and marking pens. A suitable number of 1" flat or tubular web slings in suggested pre-tied lengths of 5' and 12'; carabiners and body cords; various sizes of single and double sheave pulleys including a prussik minding pulley; various lengths of 6 - 8mm prussik cords with recommended pre-tied lengths of 53" and 65"; commercial rope grab devices such as Gibbs Ascender, Rock Exotica Ascender or equivalent; weighted objects to be lifted; and a suitable number of training lifelines to practice rigging simple mechanical advantage systems.

NFPA 1006, 2008 edition JPRs

- 5.5.2 Construct a single point anchor system
- 5.5.3 Edge protection
- 5.5.4 Construct a simple rope mechanical advantage system
- 5.5.5 Direct a team in the operation of a simple mechanical advantage system
- 5.5.6 Direct a team in the operations of a simple rope mechanical advantage system

Junior Member Statement:

Junior Member training activities should be supervised by qualified instructors to assure that the cognitive and psychomotor skills are completed in a safe and non-evasive manner. While it is critical that instructors be constantly aware of the capabilities of all students both mentally and physically to complete certain tasks safely and successfully, the instructor should take every opportunity to discuss with departmental leaders and students the maturity and job awareness each participant has for the hazards associated with fire and rescue training.

TERMINAL OBJECTIVE

The Technical Rescuer candidate, when given the appropriate equipment, shall correctly demonstrate three types of single point anchor systems and two types of simple mechanical advantage systems associated with lifting or lowering loads during various types of rescue incidents.

ENABLING OBJECTIVES

1. The Technical Rescuer candidate, when given the appropriate equipment, shall correctly demonstrate constructing various single point anchor systems used in the rescue environment.
2. The Technical Rescuer candidate, when given the appropriate equipment, shall correctly demonstrate a two-point load sharing anchor system, and a two-point and three-point load distributing anchor system.
3. The Technical Rescuer candidate, when given the appropriate equipment, shall correctly demonstrate rigging a 2:1, 3:1, and a 4:1 simple mechanical advantage system.
4. The Technical Rescuer candidate, when given the appropriate equipment, shall correctly demonstrate rigging a 4:1 mechanical advantage system using the block and tackle method.

General Ropes

Lesson Two

Anchors and Mechanical Advantage Systems

MOTIVATION

Given the fact that high and low angle rescue operations can occur in varied environments, the Technical Rescuer should be familiar with the many components of anchoring systems. This knowledge includes, suitable anchor identification, construction of anchor material, stress loads applied to anchor systems, and construction of simple mechanical advantage systems. Scenarios may include below ground confined space environments, agricultural settings involving grain bins and silos, river crossings, and many more. Since manpower is sometimes at a minimum, it's important that rescuers be proficient with various anchoring and mechanical advantage systems.

These systems, have been in existence for many centuries. From the construction of the pyramids to modern day skyscrapers, man has used these systems to make such jobs easier and safer. With the advent of new and more efficient equipment, rescue personnel can make the task more effective by decreasing the risk to rescuers and increasing the survival rate of patients.

NOTE: When performing high and low angle application skills at actual sites, all personnel should wear appropriate PPE and, use a training mannequin to simulate a patient. If a student is used as a patient, make sure all safety precautions are adhered to, including the use of a back-up safety line.

PRESENTATION

ENABLING OBJECTIVE #1

The Technical Rescuer candidate, when given the appropriate equipment, shall correctly demonstrate constructing various single point anchor systems used in the rescue environment.

1. Demonstrate rigging single point anchors.
 - a) Tensionless anchor.
 - b) Two bight anchor (sometimes referred to as a three bight anchor).
 - c) Multi-wrap anchor.
 - d) Artificial anchors
 - e) Picket systems

Reference: IFSTA Fire Service Search and Rescue, 7th Edition, pages 133 and 134

PRESENTATION

ENABLING OBJECTIVE #2

The Technical Rescuer candidate, when given the appropriate equipment, shall correctly demonstrate a two-point load sharing anchor system, and a two-point and three-point load distributing anchor system.

1. Discuss the advantages and disadvantages of a two-point load sharing anchor system.
 - a) It is useful when the integrity of a single anchor is questionable or the location of the single anchor point in relationship to the load is in an inconvenient place for attaching to the load.
 - b) If the load shifts, the disadvantage is that the weight of the load is no longer supported by both anchors.
2. When constructing any two-point anchor system the angle between the two anchor points should not exceed 90 degrees.
 - a) Angles wider than 90 degrees multiply the force on each anchor.

- b) At 120 degrees each anchor will have to support the actual load. When constructing more than a two-point anchor system, the angle between the two outer anchors should not exceed 90 degrees.
3. Demonstrate rigging a two-point load sharing anchor system.

Reference: Fire Service Search and Rescue, 7th Edition, Pages 134 and 135

4. Discuss the advantages and disadvantages of a load distributing anchor system.
- a) It is used when a single point anchor is not strong enough to support the load and a potential exists for the direction of the pull to change.
 - b) A disadvantage of this system is if the selected anchors are not individually strong enough to sustain a shock load, then an anchor could pull out causing dynamic energy on the remaining anchors thus causing a domino effect on the anchors.
5. Demonstrate rigging a two-point and a three-point load distributing anchor.

Reference: Fire Service Search and Rescue, 7th Edition, Pages 135 through 137

PRESENTATION

ENABLING OBJECTIVE #3

The Technical Rescuer candidate, when given the appropriate equipment, shall correctly demonstrate rigging a 2:1, 3:1, and a 4:1 mechanical advantage system.

1. Discuss the theory and advantage of a simple mechanical advantage system.
- a) Simple mechanical advantage systems are mainly used for low angle rescue missions are also used for some high angle rescue applications.
 - b) These systems generally provide a range of mechanical advantage from 2:1 to 4:1.
 - c) A non-mechanical hauling system is one in which the required pulling force exerted by the rescuers

is equal to the load. An example would be a 1:1 system. The load is 100 pounds and the pulling force is 100 pounds of force (lbf), thus no mechanical advantage for the pulling force is provided.

- d) A mechanical advantage system is one in which the pulling force exerted by the rescuers is less than the load. An example would be a 2:1 system. The load is 100 pounds and the pulling force needed to move the load is approximately 50 pounds of force (lbf) or half the weight of the load. This calculation does not address the size of pulleys, ropes and friction created by rope making contact with various objects or the number of bends in the rope. It is a theoretical mechanical advantage.
2. Discuss the precautions to be considered when using a mechanical advantage system.
- a) Rope and auxiliary equipment should be rated for the load being moved.
 - b) The haul line should be pulled in a steady rhythmic fashion.
 - c) No one should stand under the load.
 - d) Whenever possible the pull should be downhill.
3. Discuss the use of prussik hitches in the construction of a simple mechanical advantage system.
- a) A prussik sling at the recommended pre-tied lengths of 53" and 65" is constructed from 6 - 8mm prussik cord and tied using a double fisherman knot.
 - b) The sling is used to secure a double wrap or triple wrap prussik hitch on a rope creating a man made rope grab system.
 - c) A pulling prussik hitch seizes the rope and pulls it into motion.
 - d) A braking prussik hitch seizes the rope and prevents it from moving.
 - e) A ratchet prussik hitch allows mechanical advantage pulley systems to be reset repeatedly for multiple pulls.
 - f) Prussik hitches are usually used in tandem.
4. Suggest, as a general rule, that a tandem double-wrap prussik system be used for loads up to 300 pounds and a tandem triple-wrap prussik system be used for loads

exceeding 300 pounds on the main line. Emphasize the point that the AHJ should make the determination on how tandem double-wrap and triple-wrap prussiks should be used in technical rope operations.

- a) The selection of diameter and number of wraps should be based on the load to be moved and ultimately is the choice of the AHJ.
5. Demonstrate rigging a 2:1 simple mechanical advantage system using a commercial rope grab device rated for a one-person load.
 6. Demonstrate rigging a 3:1 Z-drag mechanical advantage system using triple wrap prussik hitches.
 7. Demonstrate rigging a 4:1 compound system.
 8. When using a mechanical advantage system to tension a line, too many people pulling on the haul line can cause critical over tensioning.
 - a) A good rule of thumb is the rule of 18 for 1/2" rope.
 - b) 6 rescuers pulling on a 3:1 MAS with 1/2" rope - $6 \times 3 = 18$

Reference:, Fire Service Search and Rescue, 7th Edition, Page 110 (use of prussiks) Pages 137 and 138 (mechanical advantage systems)

PRESENTATION

ENABLING OBJECTIVE #4

The Technical Rescuer candidate, when given the appropriate equipment, shall correctly demonstrate rigging a 4:1 mechanical advantage system using a block and tackle system.

1. Go over the parts of a block and tackle system.
 - a) Block - wooden or metal shell.
 - b) Sheaves - metal roller inside the shell.
 - c) Tackle - system incorporating 2 blocks and rope.
2. Discuss the precautions to be considered when using a block and tackle.

- a) All components of a block and tackle system should be rated for the load.
- b) The haul line should be pulled in a steady rhythmic fashion.
- c) No one should stand under the load.
- d) Whenever possible the pull should be downhill.

Reference: Fire Service Search and Rescue, 7th Edition, Page 92

3. Demonstrate using two, double sheave pulleys to reeve a 4:1 mechanical advantage system using a block and tackle system. When the hauling line (fall) comes out of the stationary block, the mechanical advantage is said to be 4:1, when the hauling line comes out of the moving block, the mechanical advantage is said to be 5:1.
4. To calculate the amount rope needed to lift a load 20' with a 4:1 block and tackle system, multiply the distance to be raised times the number of returns (reeves) through the tackle and 1 haul line, for a total of five, plus add an additional 4' for room for the chock-a-block.
 - a) Example: 20' distance to be raised or lowered x 5 returns. 100' + 4'. chock-a-block = 104'. of rope needed.
5. To calculate the load capacity of a block and tackle system, multiply the safe working load of the rope x the number of returns x 2/3.
 - a) Example: 600 pound load x 5 returns x 2/3 (.66) = 1,980 pound load capacity.
6. Point out that chock-a-block is the term used to describe the minimum distance between the anchor and the tackle at which the mechanical advantage is no longer efficient. Some texts use 4' and some texts use 3' when referencing chock-a-block.

APPLICATION

Given several weighted objects, divide the class into small groups and have them practice performing all skills listed in Enabling Objectives 1-4. The instructor should make sure all

safety precautions are adhered to including sufficient number of instructors and the use of appropriate PPE.

SUMMARY

This lesson plan addresses simple anchoring systems and mechanical advantage systems. Each system is designed to prepare the candidate to address scenarios pertaining to low and high angle rescue operations. As the Technical Rescuer candidate continues training in low and high angle environments, the candidate will be called upon to incorporate many of these anchoring systems into various rescue scenarios.