Technical Rescuer
Lesson One
Ropes Basics

DOMAIN: PSYCHOMOTOR

LEVEL OF LEARNING: KNOWLEDGE / APPLICATION

MATERIALS

IFSTA Fire Service Search and Rescue, 7th Edition; IFSTA 6th Edition Essentials of Firefighting; NFPA 1983 Fire Service Life Safety Rope and System Components Standard; laptop computer; multimedia projector; whiteboard or flipchart; and marking pens. Safe location and appropriate accessory equipment for practicing tying knots and raising and lowering equipment. Each candidate shall be provided with 1 web sling of one inch flat or tubular design of suggested pre-tied lengths of 5'; 1 practice rope for each candidate for knot tying sessions; 1 Prusik cord for each candidate at a length suitable for tying knots such as 6-8mm in diameter; various pieces of equipment to be used as props for the application and the utilization of the knots, bends and hitches shall be made available. Examples should include a forcible entry tool, a straight wall or roof ladder, and a blanket and a litter.

A display of various rope rescue hardware should be made available, examples should include steel and aluminum carabiners, tri-links, a Rescue 8 rappelling device, pulleys, rigging plates ascending devices, hardware used for controlling descents such as brake bar racks, brake tubes, any other approved rope rescue hardware used by the AHJ.

All equipment used for this lesson plan shall conform to the appropriate NFPA standards for use and safety.

NFPA 1006, 2013 Edition JPR

5.5.1 Tie knots
5.5.2 Construct a single point anchor system
5.5.3 Edge protection
5.5.4 Construct a simple MAS

5.5.5 Use a simple MAS in a raising operation
5.5.6 Function as a litter tender in a low-angle lowering or hauling operation
5.5.7 Construct a lowering system
5.5.8 Direct a lowering operation in a low-angle environment
5.5.9 Construct a belay system
5.5.10 Operate a belay system
5.5.11 Belay a falling load
5.5.12 Conduct a system safety check

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 given the appropriate equipment shall correctly identify various knots used for rescue, describe in writing their purpose, and demonstrate tying and applying the knots for various rescue applications.

ENABLING OBJECTIVES

1. The Technical Rescuer candidate shall correctly identify in writing guidelines established by NFPA and OSHA standards for the safe use of ropes, and related rope rescue equipment.

2. The Technical Rescuer candidate shall correctly describe in writing the construction characteristics and their purpose, of various types of ropes used for rescue incidents.

3. The Technical Rescuer candidate, when shown a specific rescue knot, shall correctly identify the knot and explain its use in the rescue environment.

4. The Technical Rescuer candidate, when given the appropriate rope, shall demonstrate tying various knots, including an end of the line loop, a midline loop, joining rope or webbing ends together, and gripping rope.

5. The Technical Rescuer candidate, when given the appropriate equipment and rope, shall demonstrate securing a rope to a selected piece of equipment, using the most effective knot, hitch, or bend for the purpose of hoisting the equipment.

Technical Rescuer
Lesson One
Ropes Basics

MOTIVATION

Life safety rope and related equipment is used for a variety of rescue related functions. They are designed to protect rescuers and patients as they work and move in elevated and below grade environments. The ropes, knots, and rope related rescue equipment discussed in this lesson plan will assist the rescuers with raising and lowering rescuers and patients and allow rescuers to create mechanical advantage systems. NFPA 1983 has established a set of guidelines that attempts to inform rescuers of the safe use and limitations of the ropes and related equipment. In order to operate safely at a rescue scene, it is important that rescuers have a good basic knowledge of the application, and limitations of the ropes and related rope rescue equipment being used.

NOTE: Have a display of equipment available for discussion.

PRESENTATION

ENABLING OBJECTIVE #1

The Technical Rescuer candidate shall correctly identify in writing guidelines established by NFPA and OSHA standards for the safe use of ropes, and related rope rescue equipment.

1. Discuss the criteria and purpose of NFPA 1983.
    a) These criteria are designed to address safety guidelines regarding the use of rope and related equipment that effect various fire and rescue activity.
    b) This does not apply to the use of utility rope, or special rescue operations such as wilderness

rescue, water, caving lead climbing, recreational use or industrial fall situations.

c) They are intended to provide minimum performance requirements to insure the safety of the rescuers and the general public that may be affected by the operational use of the equipment.

2. Discuss with the candidate terminology established by NFPA 1983 Standard for Fire Service Life Safety Ropes and System Components for rope rescue activities.

a) Adjusting device – a connector device that allows adjustment to a piece of equipment.
Ascent device – a friction or mechanical device utilized to allow ascension of a fixed line.

b) Rope – A compact but flexible, torsionally balanced, continuous structure of fibers produced from strands that are twisted, plaited, or braided together and that serve primarily to support a load or transmit a force from the point of origin to the point of application.

c) Block and Creel – rope constructed without knots or splices.

d) Moderate Elongation Laid Life Saving Rope. Rope dedicated solely for the purpose of supporting people during rescue at firefighting operations or training evolutions.

e) Carabiner – an oval or "D" shaped metal load bearing connector with a self-closing gate used to join other components of a rope system.

f) Descent control device – a friction or mechanical device utilized with rope to control descent.

g) Design load – the load for which a given piece of equipment, or system is rated.

h) Escape belt – certified compliant with this standard, designed for user as an emergency self rescue device

i) Escape rope – a single purpose one-time use emergency self-rescue rope. It is not classified as a life safety rope.

j) Fire escape rope – an emergency self-rescue rope used to escape an immediately hazardous environment involving fire or fire products; not classified as a life safety rope.

k) General use – previously designated as a two person load. A system or system component

designed for general use loads, light use loads, and escape.

l) Hardware – auxiliary equipment that includes but not limited to ascent devices, carabiners, descent devices, pulleys, rings, snap links, and rigging plates.

m) Impact load – sudden application of a force, which causes kinetic energy and momentum to be converted into other forms of energy.

n) Life safety harness – an arrangement of materials secured around the body used to support a person during a rescue operation.

o) Life safety rope – rope solely dedicated to supporting persons during rescue, firefighting, other emergency operations, or during training.

p) Technical use – previously designated as a one-person load. A system or system component designed for light use loads and escape.

q) Proof load – the application of force to a material as a nondestructive test to verify the performance of that material.

r) Rope grab device – auxiliary equipment used to grasp a life safety rope to support a load. It can be used as an ascension device.

s) Snap link – a self-closing, gated, load bearing connector.

t) Throw line – a floating, one-person rope intended to be thrown to a person during water rescues or as a tether for rescuers entering the water.

3. Discuss the differences between the three classes of rescue harnesses. Also discuss and demonstrate tying the modified harnesses to include the rescue knot, the seat harness, and the seat harness with chest harness.
    a. Class II – designed for rescue operations, design load is 600 lbf. A “Swiss seat” is an improvised Class II harness.
    b. Class III – designed for rescue operations. The design load is 600 lbf.
    c. The rescue knot is used for raising or lowering individuals and should be constructed using lifeline rated rope.

4. Point out that a ladder belt is not classified as a life safety harness.

5. Identify and discuss the safety checks that should be conducted for rescue harnesses.
    a. Check Class II and III rescue harness straps and buckles. Check for frayed stitching and damaged metal. Follow the manufacturer's guidelines for use, inspection, and maintenance.

6. Demonstrate the three modified harnesses listed in this lesson plan. Have the candidates practice each.
    a. Rescue knot.
    b. Seat harness.
    c. Seat harness with chest harness.

7. Illustrate various product label certification.
    a. Discuss the importance of product labeling and warning labels.

8. Discuss the classification criteria, and the recommended guidelines for using and reusing rescue rope for various rescue operations. The strengths are found as a minimum by NFPA.
    a. Technical use lifeline – diameter is 3/8" (9.5 mm) up to 1/2" (12.5 mm) with a minimum breaking strength of 4496 pounds and a maximum safe working load of 300 pounds.
    b. General use lifeline – diameter is 7/16" (11 mm) - not more than 5/8" (16 mm) with a minimum breaking strength of 8892 pounds and a maximum safe working load of 600 pounds.
    c. Escape rope – diameter is 1-9/64" (7.5 mm) - less than 3/8" (9.5 mm) with a minimum breaking strength of 3034 pounds and a maximum safe working load of 300 pounds (intended only for emergency self-rescue situations).
    d. Throw line – diameter criteria is the same as escape rope with a minimum breaking strength of 3000 pounds.

9. Discuss the criteria for using webbing in various rescue environments.
    a. Most webbing is constructed of nylon and comes in two forms, flat and tubular, and ranges in size from 1" to 2".

b. One inch tubular has a breaking strength of 4000 pounds, 1" flat webbing has a breaking strength of 6000 pounds.

10. Discuss the criteria for using accessory cord.
    a. Accessory cord is constructed of synthetic fiber and ranges in size from 6 - 8mm and is used to construct Prusik slings.
    b. Prusik slings are formed using a length of accessory cord tied with a double fisherman knot.

Reference: IFSTA Fire Service Search and Rescue, 7th Edition, page 110.

11. Discuss the design, use, and safety considerations of carabiners.
    a. Carabiners are made from hollow and solid aluminum alloy, solid steel, and stainless steel.
    b. Some manufacturers use an anodized coating for aluminum carabiners to reduce friction.
    c. The basic parts of a carabiner include the spine, gate (include knurls nut), latch, and hinge.
    d. Carabiner shapes include oval, D-shaped, and modified D-shape.
    e. The D-shaped carabiner tends to take the most advantage of the strength of the spine of the carabiner.
    f. The latching mechanism may be a pin and slot design, a claw on the gate and slot design, or a keyhole and slot design.
    g. Carabiners designated for light use shall have a minimum major axis breaking strength with the gate closed of 6000 pounds.
    h. Carabiners designated for general use shall have a minimum major axis breaking strength with the gate closed of 9000 pounds.
    i. NFPA certified carabiners will have a “P” for personal use (1995 - 2001), an “L” for light duty use (2001), or a “G” for general duty use (1995 - 2001) stamped on the carabiner.
    j. Carabiners are designed to be loaded along the long axis only.
    k. When attaching carabiners to a vertical hauling system, the gate of the carabiner should point

down to reduce the chance of the gate unlocking as a result of vibration.

l. When attaching carabiners to a horizontal hauling system, the gate of the carabiner should point towards the load to reduce the chance of the gate unlocking as a result of vibration.
m. Tri-links and semi-circle design links are non-hinged screw links recommended for multi-directional loads.
n. Inspect carabiners for wear grooves, deep gouges, sticking gate or hinges.
o. Dropping carabiners onto a hard surface may result in damage.
p. Lubricate hinges and gate knurls with dry silicone.

12. Discuss the design, use, and safety considerations of rescue rings.
    a. Steel rings are used for various load bearing applications.
    b. They are also rated as a multi-directional anchor.

13. Discuss the design, use, and safety considerations of swivels.
    a. Swivels are applied at the anchor attachment point.
    b. They must be rated for life safety loads.
    c. Swivels prevent ropes in a mechanical advantage system from twisting, and reducing the friction created by ropes rubbing on each other.

14. Discuss the design, use, and safety considerations of ascenders.
    a. Discuss that cams are used for single load ascensions and hauling systems.
    b. They are not for arresting dynamic falls.
    c. Free running cams activate only when a load is applied to the opposite end of the lever.
    d. Spring loaded cams maintain light contact with the rope at all times regardless whether or not a load is applied.

e. Handled ascenders teeth are designed for single load ascensions only. They are not used in a hauling system.
f. Demonstrate attaching an ascender to a rope.

15. Point out that when using commercial rope grab devices, follow the manufacturer's guidelines and safety precautions when incorporating these devices into a mechanical advantage system.

16. Emphasize the importance of verifying whether or not the device is designed for use in a mechanical advantage system and identify the limitations of its use.

17. Ascenders should not be used as a load capturing device.

18. Discuss the design, use, and safety considerations of figure of eight plates.
    a. They are designed as a double ring unit made of steel or anodized aluminum.
    b. They are used primarily as a descending device for rappelling.
    c. Figure of eight plates with appendages (ears) on a larger ring are commonly called Rescue 8s.
    d. The ears prevent the rope from slipping out of place and forming a girth hitch.
    e. The Rescue 8s will easily accommodate up to a 5/8" single rope or a two 7/16" ropes.
    f. Demonstrate rigging a figure of eight plate.
    g. Descent distance should be limited to 75' to 100' when using a figure of 8 plate.

NOTE: Most manufacturers advise rescuers not to use a figure of eight plate or rescue eight plates as a multi-directional load bearing device as shown in figure 4.47 on page 101 of the IFSTA Fire Service Rescue manual. Always follow manufacturer's guidelines for use.

19. Discuss the design, use, and safety considerations of rappel racks.
    a. Rappel racks are commonly referred to as a brake bar rack.

b. They are an elongated “U" shaped steel rod with an eye on one side and a threaded nut on the other side.
c. Across the rod are the friction bars.
d. The bar closest to the “U” is the largest and has a guide groove cut into it.
e. The bars can be steel or aluminum, and solid, hollow, or half moon shaped.
f. They are used as a rappelling device or a load-control descending device.
g. Friction can be changed under load by adding or subtracting friction bars. Figure 8 racks do not have this capability.
h. Many rope rescue manuals recommend this device when the need for adjusting the amount of friction to control descent is necessary and when the descent exceeds 100' because it creates less friction.

20. Discuss and give an example of a brake tube.
    a. A brake tube is a large aluminum alloy tube with a right angle vertical post and a screw locking gate, designed to function as an oversized friction device, rope is wrapped around the tube 3 - 4 times, and it can accommodate single or double ropes, and has the capability of passing a knot.

21. Discuss the design, use, and safety considerations of pulleys.
    a. Pulleys are used to reduce rope friction, to reposition a rope to a safe area, and change the direction of a running rope.
    a) The sheave or wheel should have a diameter of 4 times the diameter of the rope being used. 12.5 mm X 4 = 50mm (1/2” X 4 = 2”. 5/8” rope would require 4” pulleys).
    b. Side plates should be able to open so pulley can be placed anywhere on the rope.
    c. Side plates are the weakest link of the pulley, for high tensile strength rope (diameters above 1/2") they should be constructed of steel.
    d. Several manufacturers have produced pulleys with swivels built into them.

22. Point out that there are two types of bearings, bronze bushings, and ball bearings.
    a. Bronze bushings are very strong and can be accessed for cleaning.
    b. They are less expensive.
    c. As a disadvantage, they can be contaminated by dirt and grit.
    d. Ball bearings turn more freely than bronze bushings.
    e. Some come as sealed units preventing dirt and grit contamination.
    f. As a disadvantage, they do not take sudden blows as well as bronze bushings.

23. Show examples of the different pulleys such as single sheave pulleys, double sheave pulleys, Prusik-minding pulleys, and knot-passing pulleys.

24. Discuss the design, use, and safety considerations of rigging plates.

25. Discuss the design, use, and safety considerations of edge protectors.
    a. They reduce friction created by the rope going over the edge.
    b. They protect rope from abrasion, cuts and snags.

26. Show examples of various edge protectors such as carpet, canvas pads, fire hose, and dynamic protectors such as edge rollers.

Reference: IFSTA Fire Service Search and Rescue, 7th Edition, pages 120 through 127.

PRESENTATION

ENABLING OBJECTIVE #2

The Technical Rescuer candidate shall correctly describe in writing the construction characteristics and their purpose of various types of ropes used for rescue incidents.

1. Discuss and illustrate the characteristics of laid rope.
    a) Laid rope is constructed by twisting small bundles of fibers together and then combining them into

large bundles which are twisted around one another usually in groups of three.
   b) Surface fibers are susceptible to abrasion.
   c) They tend to be very stretchy.
   d) This rope tends to kink.
   e) Ropes of laid construction have been replaced with kernmantle style rope for life safety operations.
   f) Laid rope is used frequently for utility work.

2. Discuss and illustrate the characteristics of plaited rope.
   a) Plaited rope has bundles of fibers plaited together.
   b) It is soft and pliable.
   c) This rope is prone to picking.
   d) It is not used for life safety applications.

3. Discuss and illustrate the characteristics of the two types of braided rope.
   a) Solid braid is referred to as clothesline braid. It is a single weave of three or more bundles of fibers. It is not recommended for life safety operations.
   b) Hollow braid is a very thick sheath found with filler such as scrap yarn or filament plastic. It is commonly found in hardware stores. It is not recommended for life safety operations.

4. Discuss and illustrate the characteristics of low-stretch (static) and high-stretch (dynamic) kernmantle rope.
   a) Kernmantle is a compound German word describing the construction design of the rope.
   b) Kern refers to the core of the rope that supports the major load on the rope.
   c) Mantle refers the outer woven sheath of the rope that supports a lesser portion of the load on the rope.
   d) The construction design produces a rope that is strong and easy to handle, unlike laid rope it does not tend to twist or kink under load.
   e) Low-stretch (static) kernmantle is the rope of choice for rescue operations in which human life will be in direct contact with the rope.
   f) The core bundles of static kernmantle are nearly parallel to each other creating a low stretch rope.

g) Low-stretch (static) kernmantle is considered as a low stretch rope designed to absorb low impact loads reducing the risk of rope failure. It has a thick and tight sheath providing greater resistance to abrasion reducing the ability of dirt and grit from penetrating the core.
h) High-stretch (dynamic) kernmantle is considered a high stretch rope designed to absorb high impact loads reducing the risk of rope failure.
i) The inner core is constructed of twisted bundles that allow the rope to stretch under a load allowing the rope to absorb a lot of energy.
j) The exterior of braided rope and braid on rope, can be mistaken for Kernmantle rope. These ropes are not designed for life loads but for utility applications.

5. Discuss the inspection, care and maintenance of lifeline rope.
   a) The criterion for the inspection and care of lifeline rope is established by NFPA 1983.
   b) Check for visible damage, such as a cut sheath or core, or soft spots on the sheath.
   c) Check for irregular shape, foul smell, and discoloration.
   d) Make sure rope has not been exposed to heat, direct flame impingement, or abrasion. Mild abrasion after multiple uses is normal.
   e) Rope has not been subjected to any shock load.
   f) Rope has not been exposed to liquids, solids, gases, mist or vapors of any chemicals or other products that can deteriorate the rope.
   g) Rope passes inspection when inspected by a qualified person following the manufacturer's procedure both before and after each use.
   h) Rope not passing inspection should be discarded or cut into short lengths and used as utility rope.
   i) Rope logs should be maintained for each lifeline for the duration of its in-service life.
   j) Many rope rescue experts recommend a shelf life for lifeline of 5-7 years and not to exceed 10 years. Check with manufacturer.
   k) A rope log should reflect types of usage and maintenance. Provide a sample rope log.

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

pages 111 through 113; Manufacturer's Specification manuals.

6. Emphasize that the individuals responsible for care and maintenance should have a thorough knowledge of lifeline construction and characteristics and potential hazards and limitations resulting from in-field application and be well versed with the NFPA 1983 ropes and ancillary equipment standard.

APPLICATION

Given rope, webbing, and a rescue harness have the candidates demonstrate the inspection procedures for each.

7. Discuss procedures for cleaning rope.
   a) Point out that methods of washing and drying rope vary from manufacturer to manufacturer.
   b) Cool water and, if needed, a small mild soap are least likely to damage rope.
   c) Rope can be cleaned by hand, commercial rope washer or front load washer without a plastic window. Do not use a top-loading washer.
   d) Washers should be set on the coolest wash/rinse temperature.
   e) Rope should be placed in a cloth or mesh bag or coiled like an electrical cord (Bird's Nest).
   f) Rope can be dried on a hose rack, suspended in a hose tower or loosely coiled in a hose dryer.
   g) Keep rope from extended exposure to direct sunlight.
   h) Once cleaned, rope should be coiled or stuffed into rope bag.
   i) Rope should be kept in a clean dry compartment void of any contaminants.
   j) Cleaning guidelines for webbing, Prusik cords, and rescue harnesses constructed of synthetic materials should parallel guidelines for rope.

Reference: Fire Service Search and Rescue, 7th Edition, pages 111 through 113; Manufacturer's Specification manuals.
Reference: IFSTA Fire Service Search and Rescue, 7th edition, pages 108 through 110.

PRESENTATION

ENABLING OBJECTIVE #3

The Technical Rescuer candidate, when shown a specific rescue knot, shall correctly identify the knot and explain its use in the rescue environment.

1. Identify the criteria for selecting an appropriate knot for a specific task.
    a) A knot should be easy to tie, easy to untie and be secure under load.
    b) A rope's strength is reduced when it is bent, the tighter the bend, the more strength is reduced.
    c) Some knots create tighter bends than others and reduce the strength of the rope to a greater degree.

Reference IFSTA Fire Service Search and Rescue, 7th Edition, page 128.

2. Discuss the application of the various knots.
    a) Joining/Connecting knots.
    b) Loop Forming knots.

Reference: IFSTA Fire Service Search and Rescue, 7th Edition, pages 128 through 132.

PRESENTATION

ENABLING OBJECTIVE #4

The Technical Rescuer candidate when given the appropriate rope shall demonstrate tying various knots, including an end of the line loop, a midline loop, joining rope or webbing ends together, and gripping rope.

1. Demonstrate tying the following knots, bends and hitches.
    a) Overhand knot.
    b) Double fisherman knot.
    c) Figure-of-eight bend.
    d) Figure-of-eight knot.
    e) Figure-of-eight-on–a-bight.
    f) Bowline knot.
    g) Water knot.
    h) Directional figure-of-eight knot.
    i) Clove hitch.

j) Prusik knot.
k) Rescue knot using a bowline-on-a-bight or a double loop figure-of-eight knot for the leg loops.
l) Butterfly knot.
m) Half-hitch.

Reference: IFSTA Fire Service Search and Rescue, 7th Edition, pages 128 through 132.

PRESENTATION

ENABLING OBJECTIVE #5

The Technical Rescuer candidate when given the appropriate equipment and rope shall demonstrate securing a rope to a selected piece of equipment, using the most effective knot, hitch, or bend for the purpose of hoisting the equipment.

1. Demonstrate securing a utility rope to an axe for the purpose of hoisting the axe.
   a) Using one end of the rope, tie a long tail bowline around the head of the axe and secure a half - hitch near the end of the handle. The tail becomes the tag line.

2. Demonstrate securing a utility rope to a prying tool for the purpose of hoisting the prying tool using a closed clove hitch and half-hitch.

3. Demonstrate securing a utility rope to a ladder for the purpose of hoisting the ladder using a bowline knot.

4. Demonstrate securing a utility rope to a blanket for the purpose of hoisting the blanket using an open clove hitch.
   a) Form a large open clove hitch in the utility rope and insert a rolled up blanket into the open clove hitch and dress down tightly.

5. Demonstrate hoisting a ground ladder using a bowline knot.

Reference: IFSTA Essentials of Firefighting, 5th Edition, pages 279 through 282.

APPLICATION

Divide the candidates into small groups. Make sure each candidate has the appropriate equipment. Set up a knot tying station and an equipment hoisting station, demonstrate the procedures listed in Enabling Objectives 4 and 5. Have each candidate rotate through each station and practice the skills listed for the station. The above set-up is only a recommendation, as the instructor, you will have to decide the most effective way of setting up the skill sessions so as to allow optimum practice time.

SUMMARY

Review the uses of the various kinds of ropes, knots, and related equipment. Use the application listed in the lesson plan above to increase the candidate's skill level for tying knots and applying them to various rescue applications.