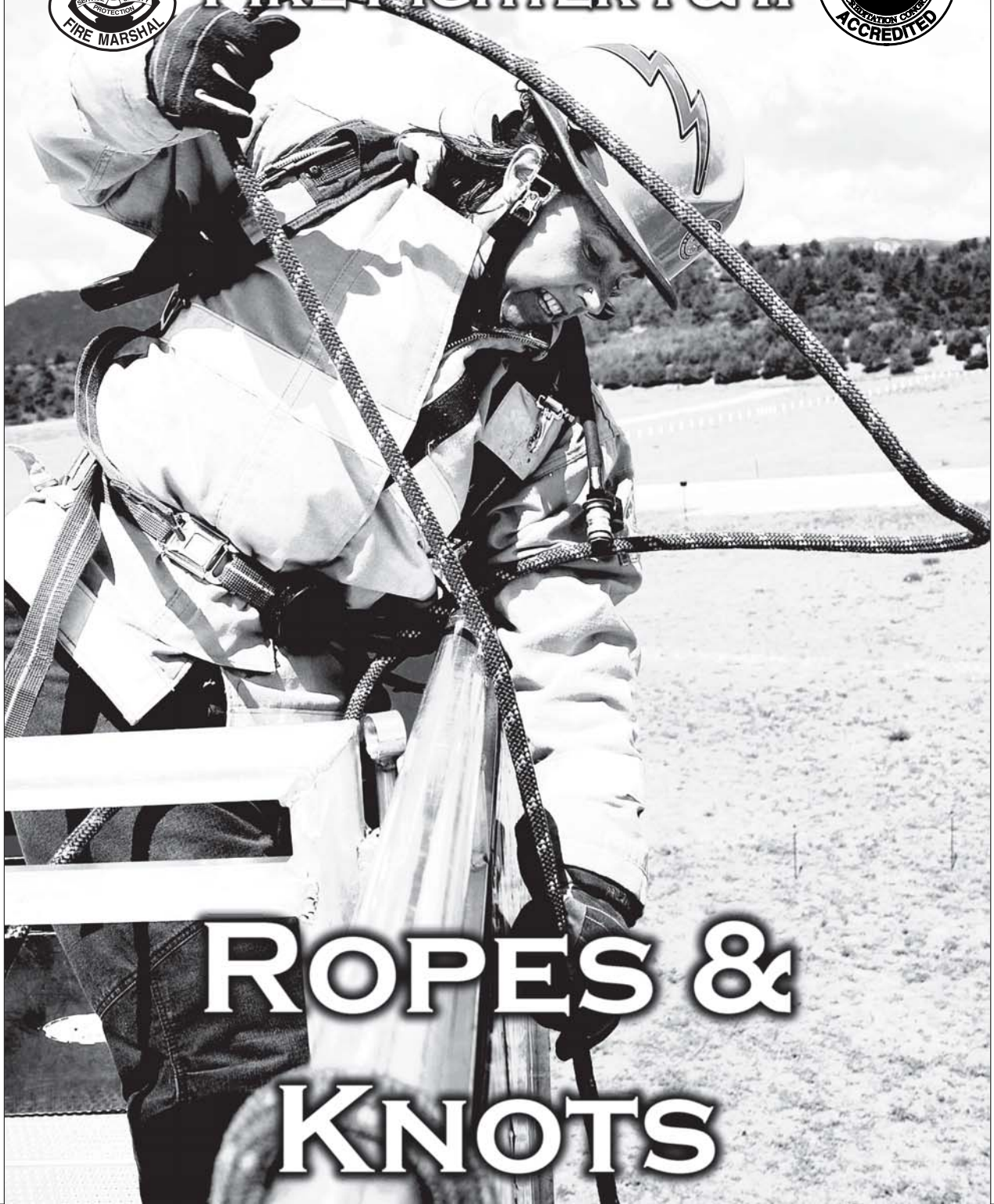




Missouri Division of Fire Safety  
**FIRE FIGHTER I & II**



**ROPES &  
KNOTS**





### UNIT OBJECTIVES

Upon completion of this unit of study, the student should be able to:

1. Explain the difference between life safety and utility rope.
2. Describe the various materials from which rope is constructed.
3. Describe the types of construction used for fire service rope.
4. Demonstrate the techniques for inspecting rope.
5. Demonstrate the proper cleaning, maintenance, and storage of rope.
6. Describe the method of marking a rope to remove it from service.
7. Identify the parts of the knot and explain their applications.
8. Demonstrate tying each of the following knots:
  - a. Overhand safety
  - b. Figure-eight on a bight
  - c. Becket or sheet bend
  - d. Bowline
  - e. Clove hitch
  - f. Half hitch
9. Demonstrate using an appropriate knot and rope to hoist tools and equipment.



### NFPA STANDARDS

*Successful completion of the information in this section is necessary to fulfill the requirements of the following sections of NFPA 1001-2008:*

#### **Fire Fighter I Standard**

**5.1.1 General Knowledge Requirements.** The organization of the fire department; the role of the Fire Fighter I in the organization; the mission of fire service; the fire department's standard operating procedures (SOPs) and rules and regulations as they apply to the Fire Fighter I; the role of other agencies as they relate to the fire department; aspects of the fire department's member assistance program; the importance of physical fitness and a healthy lifestyle to the performance of the duties of a fire fighter; the critical aspects of NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, as they apply to the Fire Fighter I; knot types and usage; the difference between life safety and utility rope; reasons for placing rope out of service; the types of knots to use for given tools, ropes, or situations; hoisting methods for tools and equipment; and using rope to support response activities.

**5.1.2 General Skill Requirements.** The ability to don personal protective clothing within 1 minute; doff personal protective clothing and prepare for reuse; hoist tools and equipment using ropes and the correct knot; and locate information in departmental documents and standard or code materials.

**5.5.1** Clean and check ladders, ventilation equipment, SCBA, ropes, salvage equipment, and hand tools, given cleaning tools, cleaning supplies, and an assignment, so that equipment is clean and maintained according to manufacturer's or departmental guidelines, maintenance is recorded, and equipment is placed in a ready state or reported otherwise. **(A) Requisite Knowledge.** Types of cleaning methods for various tools and equipment, correct use of cleaning solvents, and manufacturer's or departmental guidelines for cleaning equipment and tools.

**(B) Requisite Skills.** The ability to select correct tools for various parts and pieces of equipment, follow guidelines, and complete recording and reporting procedures.



NOTES	STUDENT GUIDE
	<p><b>I. Fire Service Ropes and Knots</b> (<i>Essentials p. 263</i>)</p> <p>A. The fire service has depended on the use of ropes since its beginnings</p> <p>B. Ropes are useful for:</p> <ol style="list-style-type: none"><li>1. Hoisting equipment</li><li>2. Gaining access</li><li>3. Rescuing people</li><li>4. Stabilizing equipment and vehicles</li></ol> <p>C.</p> <ol style="list-style-type: none"><li>1.</li><li>2. Must be constructed of continuous filament fiber</li><li>3. Must conform to NFPA 1983, <i>Standard on Fire Service Life Safety Rope and System Components</i></li><li>4. Life safety rope must be used only for supporting people during rescue, fire fighting, or other emergency operations, or during training</li><li>5. Manufacturers must supply information on use criteria, inspection procedures, and criteria on removing life safety rope from service which include:<ol style="list-style-type: none"><li>a. Not visibly damaged</li><li>b. No signs of abrasions or heat damage</li><li>c. Not been impact loaded from a sudden stop with a falling load</li></ol></li></ol>



NOTES	STUDENT GUIDE
	<ul style="list-style-type: none"><li>d. Not exposed to any chemicals</li><li>e. Pass inspection by a qualified person before and after each use</li></ul> <p>6. Life safety ropes which fails an inspection or been impact loaded must immediately be changed in one these manners:</p> <ul style="list-style-type: none"><li>a. Altered so it cannot be mistaken for life-safety rope and inadvertently used again</li><li>b. Disposed of entirely</li><li>c. Have the manufacturer's label removed</li><li>d. Cut into shorter lengths</li><li>e.</li></ul> <p>D.</p> <ul style="list-style-type: none"><li>1.</li><li>2. No standards for utility line applications</li></ul> <p>E. Webbing</p> <ul style="list-style-type: none"><li>1. Webbing is often used with ropes</li><li>2. Most webbing is made from the same materials as synthetic rope and requires the same care</li><li>3. One-inch webbing is the most common webbing used in the fire service</li><li>4. Webbing may be of solid flat design or a tubular design</li></ul>



NOTES	STUDENT GUIDE
	<p data-bbox="570 409 1081 443"><b>II. Rope Materials and Construction</b></p> <p data-bbox="618 485 992 518">A. Materials used for ropes</p> <p data-bbox="667 562 899 596">1. Natural fibers</p> <ul data-bbox="716 642 1268 1052" style="list-style-type: none"><li data-bbox="716 642 737 676">a.</li><li data-bbox="716 716 1182 749">b. Can be used for utility purposes</li><li data-bbox="716 789 1268 823">c. Most natural fibers ropes are made of:<ul data-bbox="764 867 915 1052" style="list-style-type: none"><li data-bbox="764 867 889 900">(1) Sisal</li><li data-bbox="764 940 915 974">(2) Manila</li><li data-bbox="764 1014 911 1052">(3) Cotton</li></ul></li></ul> <p data-bbox="667 1096 688 1129">2.</p> <ul data-bbox="716 1173 1365 1856" style="list-style-type: none"><li data-bbox="716 1173 1187 1207">a. Used for life-safety applications</li><li data-bbox="716 1247 737 1281">b.</li><li data-bbox="716 1320 1273 1354">c. Excellent strength and easy to maintain</li><li data-bbox="716 1394 1365 1472">d. May have continuous fibers running the entire rope length</li><li data-bbox="716 1512 1235 1545">e. Synthetic materials commonly used:<ul data-bbox="764 1589 1013 1856" style="list-style-type: none"><li data-bbox="764 1589 899 1623">(1) Nylon</li><li data-bbox="764 1663 948 1696">(2) Polyester</li><li data-bbox="764 1736 992 1770">(3) Polyethylene</li><li data-bbox="764 1810 1013 1843">(4) Polypropylene</li></ul></li></ul>



NOTES	STUDENT GUIDE
	<ul style="list-style-type: none"><li>(5) Kevlar Aramid</li><li>(6) Spectra polyethylene<ul style="list-style-type: none"><li>(a) Ultra high molecular weight polyethylene (UHMWPE)</li><li>(b) Rated best for strength and abrasion resistance</li></ul></li></ul> <p>B. Types of rope construction</p> <ul style="list-style-type: none"><li>1. For life-safety applications, rope will be:<ul style="list-style-type: none"><li>a.<ul style="list-style-type: none"><li>(1) Designed to stretch without breaking</li><li>(2) Used when long falls are a possibility</li><li>(3)</li></ul></li><li>b.<ul style="list-style-type: none"><li>(1)</li><li>(2) Used for most rope-rescue situations where falls are not likely or very short falls are possible</li><li>(3) Must not elongate more than 10% when tested to a load equal to 10% of its breaking strength</li></ul></li></ul></li></ul>



NOTES	STUDENT GUIDE
	<p>c. NFPA 1983 requirements for life safety rope:</p> <ul style="list-style-type: none"><li>(1) Light-use rope<ul style="list-style-type: none"><li>(a) Intended for the weight of one person</li><li>(b) 4,500 pounds minimum breaking strength</li><li>(c) 300 pound maximum safe working load limit</li><li>(d) Between <math>\frac{3}{8}</math>-inch and <math>\frac{1}{2}</math>-inch in diameter</li></ul></li><li>(2)<ul style="list-style-type: none"><li>(a)</li><li>(b) 9,000 pounds minimum breaking strength</li><li>(c) 600 pound maximum safe working load limit</li><li>(d) Between <math>\frac{7}{16}</math>-inch and <math>\frac{5}{8}</math>-inch in diameter</li></ul></li><li>(3) Throwline rope<ul style="list-style-type: none"><li>(a) Used to tether rescuers during water rescue or to throw to a victim in the water</li><li>(b) 3,000 pounds minimum breaking strength</li><li>(c) 200 pound maximum safe working load limit</li><li>(d) Between <math>\frac{19}{64}</math>-inch and <math>\frac{3}{8}</math>-inch in diameter</li></ul></li></ul>



NOTES	STUDENT GUIDE
	<p>(4)</p> <ul style="list-style-type: none"><li>(a) Not considered either life-safety or utility rope</li><li>(b) Must meet the same requirements as throwline</li><li>(c)</li></ul> <p>2. Kernmantle - jacketed rope</p> <ul style="list-style-type: none"><li>a. Constructed of a braided covering or sheath (mantle) over a core (kern) of the main load bearing strands</li><li>b. The core runs parallel to the covering increasing its strength</li><li>c. The kern accounts for about 75% of the rope's strength</li><li>d. The mantle provides the rest of the rope's strength and protects the core from abrasion and contamination</li><li>e.</li><li>f. High-stretch kernmantle is used typically for recreational rock climbing</li></ul> <p>3. Laid (twisted) rope</p> <ul style="list-style-type: none"><li>a. Constructed by twisting yarns together to form strands</li></ul>



NOTES	STUDENT GUIDE
	<ul style="list-style-type: none"><li>b. Most vulnerable to physical damage by abrasion because all load-bearing strands are exposed</li><li>c.</li></ul> <p>4. Braided rope</p> <ul style="list-style-type: none"><li>a. Constructed by intertwining strands together</li><li>b. Can be subject to direct abrasion and damage</li><li>c. Used as utility rope</li></ul> <p>5. Braid-on-braid (double braid) rope</p> <ul style="list-style-type: none"><li>a. Constructed with a braided core and a braided jacket</li><li>b. Considered strong due to each braid taking half of a load</li><li>c. Does not resist abrasion as well as kernmantle rope</li><li>d. Outer sheath may slide along inner core</li></ul> <p>C. Factors affecting rope strength</p> <ul style="list-style-type: none"><li>1.</li><li>2.</li><li>3. Chemical contact</li><li>4. Sunlight and ultraviolet light</li><li>5.</li><li>6. Heat</li></ul>



NOTES	STUDENT GUIDE
	<p>7. Mold and mildew (natural fiber ropes)</p> <p>8. Moisture (natural fiber ropes)</p> <p><b>III. Rope Inspection, Cleaning, and Storage</b> (<i>Essentials p. 269</i>)</p> <p>A. Inspection</p> <ol style="list-style-type: none"><li>1.</li><li>2. Follow manufacturer's recommendations</li><li>3. Label or identify all ropes</li><li>4. Keep a maintenance log</li><li>5.</li><li>6. Inspect all ropes for:<ol style="list-style-type: none"><li>a. Foreign materials in rope</li><li>b.</li><li>c. Chemical damage</li><li>d.</li></ol></li><li>7. Kernmantle rope inspection<ol style="list-style-type: none"><li>a.</li><li>b. Put a slight tension on rope and feel for lumps, depressions, or soft spots</li><li>c. Outer sheath damage may indicate core damage</li></ol></li></ol>



NOTES	STUDENT GUIDE
	<ul style="list-style-type: none"><li>d.</li><li>e. Check for irregularities in the shape or weave</li><li>f. If there is any doubt about a kernmantle rope's integrity, it should be downgraded to utility rope status</li></ul> <p>8. Synthetic laid rope inspection</p> <ul style="list-style-type: none"><li>a. Check externally and untwist and check internally for:<ul style="list-style-type: none"><li>(1) Soft, crusty, stiff, or brittle spots</li><li>(2) Cuts, nicks, or abrasions</li><li>(3) Chemical damage</li><li>(4) Dirt or grease</li></ul></li><li>b.</li></ul> <p>9. Braided rope inspection</p> <ul style="list-style-type: none"><li>a. Check for unusual fuzziness</li><li>b. Feel for mushy spots and deformities</li></ul> <p>10. Braid-on-braid rope inspection</p> <ul style="list-style-type: none"><li>a. Check for sheath sliding on core</li><li>b. Feel for lumps that indicate core damage</li></ul>



NOTES	STUDENT GUIDE
	<p>B. Removing rope from service</p> <ol style="list-style-type: none"><li>1. Chemical contamination</li><li>2. Age</li><li>3. Uneven diameter or texture</li><li>4. Excessive sheath wear</li><li>5.</li></ol> <p>C. Maintain a rope log</p> <ol style="list-style-type: none"><li>1. New rescue rope should be marked on the ends with an identification number and the date it was placed in service</li><li>2. A record (log) should be made and kept throughout the rope's life</li><li>3. The dates of each use and inspection should be entered into the rope log</li><li>4. The log helps determine when a rope should be retired</li></ol> <p>D. Cleaning rope</p> <ol style="list-style-type: none"><li>1.<ol style="list-style-type: none"><li>a.</li><li>b. Wipe or gently brush</li></ol></li><li>2. Synthetic fibers<ol style="list-style-type: none"><li>a. Follow manufacturer's directions</li></ol></li></ol>



NOTES	STUDENT GUIDE
	<ul style="list-style-type: none"><li>b. Clean with cool water and mild soap</li><li>c. Avoid bleach and harsh detergents</li><li>d. Methods for cleaning synthetic rope<ul style="list-style-type: none"><li>(1) Hand wash</li><li>(2) Rope washer</li><li>(3) Clothes washer should be used for a more thorough cleaning</li></ul></li><li>e.</li></ul> <p>E. Rope storage</p> <ul style="list-style-type: none"><li>1. Rescue rope should be stored in spaces that are clean and dry with adequate ventilation<ul style="list-style-type: none"><li>a. Rope should not be exposed to chemical contaminants or fumes</li><li>b.</li></ul></li><li>2. Rope bag<ul style="list-style-type: none"><li>a. Rope bags are best for storing life-safety ropes</li><li>b. Rope can be quickly deployed by holding the rope end and throwing or dropping the bag</li><li>c. The rope's weight carries the bag toward the target as the rope plays out</li><li>d.</li></ul></li></ul>



NOTES	STUDENT GUIDE
	<p data-bbox="667 411 1052 443">3. Coiling a rope for storage</p> <ul data-bbox="716 489 1390 667" style="list-style-type: none"><li data-bbox="716 489 1390 558">a. Coiled rope must be capable of being placed in service with a minimum of delay</li><li data-bbox="716 604 1390 667">b. Improperly coiled rope may tangle and fail to uncoil</li></ul> <p data-bbox="570 753 946 785"><b>IV. Knots</b> (<i>Essentials p. 274</i>)</p> <ul data-bbox="618 831 1357 1776" style="list-style-type: none"><li data-bbox="618 831 1357 905">A. Knots are used to connect ropes or webbing, form loops, and attach ropes or webbing or objects</li><li data-bbox="618 947 1357 1020">B. Improperly tied knots are hazardous to rescuers and victims</li><li data-bbox="618 1062 1357 1136">C. Instructions for tying knots include understanding the terms for the parts of a rope:<ul data-bbox="667 1171 894 1440" style="list-style-type: none"><li data-bbox="667 1171 894 1203">1. Running part:</li><li data-bbox="667 1287 894 1318">2. Working end:</li><li data-bbox="667 1402 894 1434">3. Standing part:</li></ul></li><li data-bbox="618 1518 1357 1591">D. All knots should be "dressed" after being tied: tightened until snug with no slack</li><li data-bbox="618 1633 1357 1776">E. Knots can sometimes loosen or fail from repeated loading and unloading<ul data-bbox="667 1749 691 1780" style="list-style-type: none"><li data-bbox="667 1749 691 1780">1.</li></ul></li></ul>



NOTES	STUDENT GUIDE
	<p>2. Safety knots include the single- and double-over-hand knots</p> <p>F. Practice is the key to competence and confidence in tying fire service knots</p> <p>G. Elements of a knot</p> <ol style="list-style-type: none"><li>1. A fire service knot must be easy to tie and untie and be secure under load</li><li>2.<ol style="list-style-type: none"><li>a. The tighter the bend, the more strength lost</li><li>b. Some knots create tighter bends</li></ol></li><li>3. Knots and hitches are formed using these bends:<ol style="list-style-type: none"><li>a. _____ - formed by bending the rope back on itself while keeping the sides parallel</li><li>b. _____ - made by crossing the side of the bight over the standing part</li><li>c. _____ - further bending the sides of a loop</li></ol></li></ol> <p>H. Overhand safety knot</p> <ol style="list-style-type: none"><li>1.</li><li>2. Eliminates danger of end slipping back through knot</li></ol> <p>I.</p> <ol style="list-style-type: none"><li>1. One of the most important fire service knots</li></ol>



NOTES	STUDENT GUIDE
	<ul style="list-style-type: none"><li>2.</li><li>3. Easily untied</li></ul> <p>J.</p> <ul style="list-style-type: none"><li>1. Always used in conjunction with other knots</li><li>2.</li><li>3. Formed by making a round turn around an object<ul style="list-style-type: none"><li>a. The rope's standing part is passed under the round turn on the side opposite the intended direction of the pull</li><li>b. Several half-hitches can be applied in succession if required</li></ul></li></ul> <p>K.</p> <ul style="list-style-type: none"><li>1. Consists of two half hitches</li><li>2. Used to attach rope to poles, posts, hose and to hoist round objects</li><li>3.</li><li>4. Can be formed anywhere in a rope</li><li>5. Can withstand a steady pull in either direction without slipping</li><li>6. Should be backed with an overhand safety knot</li></ul>



NOTES	STUDENT GUIDE
	<ul style="list-style-type: none"><li>L. Figure-eight family of knots on a bight<ul style="list-style-type: none"><li>1. Figure-eight<ul style="list-style-type: none"><li>a. Foundation for the group of figure eights</li><li>b. Can be used as a "stopper" knot so a rope will not pass through the grommet of rope bag or a rescue pulley</li></ul></li><li>2. Figure-eight bend<ul style="list-style-type: none"><li>a. Also known as the "Flemish Bend"</li><li>b. Used on life-safety rope to tie ropes of equal diameter together</li></ul></li><li>3.<ul style="list-style-type: none"><li>a.</li><li>b. Tied by forming a bight at each end of a rope and then tying a simple figure-eight with the bight in the double part of the rope</li></ul></li><li>4. Figure-eight follow through<ul style="list-style-type: none"><li>a. Used to secure a rope around an object</li><li>b. A single figure-eight is tied and then the end of the rope is wrapped around an object and follows back through the single figure-eight</li></ul></li></ul></li></ul>



NOTES	STUDENT GUIDE
	<p>M.</p> <ol style="list-style-type: none"><li>1.</li><li>2. Unlikely to slip with wet rope</li><li>3. Not suitable for life safety work</li></ol> <p>N. Water knot</p> <ol style="list-style-type: none"><li>1. Preferred knot for joining two pieces of webbing or the ends of one piece when a loop is needed</li></ol> <p><b>V. Rope Hardware</b></p> <p>A. Numerous hardware items are used with ropes and webbing, primarily in rope rescue</p> <p>B. Carabiner: a metal snap link used to connect elements of a rescue system together</p> <p>C. Figure-eight plate (descender): used for rappelling or as a friction brake in lowering systems</p> <p>D. Brake bar rack (descender): used for rappelling or as a friction brake</p> <p>E. Ascender: used to ascend a vertical rope</p> <p>F. Pulleys: used in rescue systems to change the direction of pull or create mechanical advantage</p> <p><b>VI. Hoisting Equipment</b></p> <p>A. The most common use of ropes is to raise or lower tools and equipment from one level to another</p>



NOTES	STUDENT GUIDE
	<p>B.</p> <p>C. A tagline or guideline should be tied to the piece of equipment to prevent the equipment from contacting the building when being raised</p> <p>D. Hoisting Safety</p> <ol style="list-style-type: none"><li>1. Always have a solid footing</li><li>2.</li><li>3. Protect rope from sharp edges with an edge roller or padding</li><li>4.</li><li>5. Make sure area is clear of personnel and electrical hazards before hoisting any equipment</li><li>6. If hoisting a charged hoseline, secure nozzles from accidentally opening</li><li>7.</li></ol> <p>E. Pike pole</p> <ol style="list-style-type: none"><li>1. A clove-hitch is placed near the end of the handle with a half hitch near the middle and another half hitch around the head</li><li>2.</li></ol>



NOTES	STUDENT GUIDE
	<p data-bbox="618 411 711 443">F. Axe</p> <ol data-bbox="667 489 1406 785" style="list-style-type: none"><li data-bbox="667 489 1406 596">1. A clove hitch is tied near the axe head and the working end of the rope is looped around the head and back up the handle</li><li data-bbox="667 642 1406 709">2. A half hitch is tied on the handle a few inches above the clove hitch</li><li data-bbox="667 756 1406 785">3. A second half hitch is tied near the end of the handle</li></ol> <p data-bbox="618 831 862 863">G. Ground ladder</p> <ol data-bbox="667 909 1406 1087" style="list-style-type: none"><li data-bbox="667 909 1406 976">1. A bowline or a figure-eight on a bight is tied and slipped through the first two rungs of the ladder</li><li data-bbox="667 1022 1406 1087">2. After pulling the loop through, slip it over the top of the ladder</li></ol> <p data-bbox="618 1134 786 1165">H. Hoseline</p> <ol data-bbox="667 1211 1406 1892" style="list-style-type: none"><li data-bbox="667 1211 764 1243">1. Dry<ol data-bbox="716 1289 1406 1585" style="list-style-type: none"><li data-bbox="716 1289 1406 1356">a. Fold the nozzle end of the hoseline back over the rest of the hose for about four feet</li><li data-bbox="716 1402 1406 1470">b. Tie a clove hitch and an overhand safety knot over the nozzle and hose it is against</li><li data-bbox="716 1516 1406 1585">c. Secure the doubled end with a half hitch about 12-inches from the loop end</li></ol></li><li data-bbox="667 1631 824 1663">2. Charged<ol data-bbox="716 1709 1406 1892" style="list-style-type: none"><li data-bbox="716 1709 1406 1776">a. Tie a clove hitch and an overhand safety knot around the hose about one-foot below the nozzle</li><li data-bbox="716 1822 1406 1892">b. Tie a half hitch through the nozzle handle and nozzle to allow the rope to hold the nozzle shut</li></ol></li></ol>



NOTES	STUDENT GUIDE
	<ul style="list-style-type: none"><li>I. Smoke ejector: tie a bowline or figure-eight on a bight around two connecting rods between the front and back plates</li> <li>J. Power saw<ul style="list-style-type: none"><li>1. Secure the rope to saw's handle with a figure-eight on a bight or bowline</li> <li>2. Leave enough excess running end so it can be a tagline</li></ul></li></ul> <p><b>VII. Rescue Rope and Harness</b></p> <ul style="list-style-type: none"><li>A. Sometimes the only method to get to a victim above or below grade may be the use of ropes and rope systems</li> <li>B. Rope rescue is a technical skill requiring specialized training and should not be attempted by untrained personnel</li> <li>C. Rescue rope and harnesses are used to protect rescuers and victims and accomplish these rescues safely</li> <li>D. Rescue harnesses<ul style="list-style-type: none"><li>1. Ladder belts are not approved as a harness and considered only as positioning devices on ladders and for emergency escape</li> <li>2.<ul style="list-style-type: none"><li>a.</li> <li>b. Fastens around the waist and around the thighs or under the buttocks</li></ul></li></ul></li></ul>



NOTES	STUDENT GUIDE
	<ul style="list-style-type: none"><li>c. Intended for emergency escape for up to 300 pounds</li></ul> <p>3. Class II harness</p> <ul style="list-style-type: none"><li>a. Fastens exactly like a Class I harness</li><li>b. Rated for up to 600 pounds</li><li>c. The label must be checked to determine if it is a Class I or Class II harness</li></ul> <p>4.</p> <ul style="list-style-type: none"><li>a.</li><li>b. Fastens around the waist, around the thighs or under the buttocks, and over the shoulders</li><li>c. Rated for up to 600 pounds</li></ul> <p><b>VIII. Ropes and Knots Summary</b></p> <ul style="list-style-type: none"><li>A. Rope is one of the oldest tools in the fire service</li><li>B. Ropes are used to stabilize vehicles and equipment, hoist and lower tools and equipment, and rescue victims</li><li>C. Fire fighters must be proficient in quickly and correctly tying the appropriate knot for the task or their safety can be at risk as well the condition of other equipment being used</li><li>D. Continual practice is the key to competence and confidence in mastering fire service knots</li></ul>