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ABSTRACT

The document presents a rationale for expanding the current emergency skills curriculum in North Carolina's 18 multi-vehicle range laboratories for driver education, and includes a review of past and current programs in other locations, a review of past North Carolina accident studies directly related to this area, and a recommended set of resources. A variety of driver education research studies with relevant accident data are examined in a review of literature. The skills needed to react properly in an emergency situation are discussed, in terms of various programs and their results, and the feasibility for implementing these skills into existing programs is examined. Recommendations for emergency driving skills resources include the implementation of a small scale pilot program that could be accurately evaluated, and the teaching of the following maneuvers in existing driving ranges: (1) serpentine maneuver, (2) evasive maneuver, (3) controlled braking, (4) off-road recovery, (5) skid control, and (6) mechanical emergencies. Information regarding space requirements, materials needed, diagrams, and cost, where determined, are included. Appended material includes a General Motors accident research bibliography of 18 titles, and a summary of maneuvers in other programs. (LH)

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Highway Safety Research Center

Emergency Skills Resources for

Range-Related Driver Education

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TABLE OF CONTENTS

I. INTRODUCTION

As part of the expansion and evaluation of North Carolina's driver education program, the need for an emergency skills curriculum has been suggested. The scope of this report is to evaluate the currently existing and operating emergency skills programs and to recommend a set of resources to the Department of Public Instruction. On the basis of these recommendations and internal inputs, the Department of Public Instruction can initiate a pilot study in the following year to further evaluate the effectiveness of such a program. Should this program prove effective, it could be instituted on a statewide basis.

This proposed expansion of the current statewide driving range program is in line with recommendations presented in the accident-oriented evaluation of the program by Council, Roper, and Sadof (1975). The final section of this reference paper notes the lack of accident-related differences between range and non-range programs and the higher costs associated with the range program. The need for continued upgrading of the current program is cited and two of many possible avenues are suggested: (1) expansion of the program scope through innovative curriculum changes, and (2) expansion of the program through addition of traditional users and new users in new programs. The implementation of a new motorcycle driver education would fall under the second of these avenues. The emergency skills programs discussed here could be categorized in the former. The following discussion will present the rationale for this new program, a review of past and current programs in other locations, a review of past N.C. accident studies directly related to this area, and a recommended set of resources.

In the course of the driving experience, the driver is likely to find himself in a situation where the normal (basic) set of manipulative and decision making skills are not sufficient to overcome the problem. The driver education student is taught in the classroom to drive defensively to avoid collisions and how to handle an emergency, but in most cases he is not given behind-the-wheel training in these emergency situations.

What are emergency situations? Why should we train young drivers for emergency situations? How do we know training of this nature will work? Is this type of training possible for North Carolina drivers with the existing system of driving ranges? These are some of the questions that are important to examine in order to prepare an effective "emergency driving procedure" curriculum.

It seems appropriate to start with a working definition of "emergency maneuver." An emergency maneuver is a coordinated effort by the driver of a vehicle implemented in a compressed time interval for the purpose of 1) avoiding an obstruction in the path of that vehicle, or 2) keeping the vehicle in control when a malfunction occurs or the normal forces of friction (and traction) are not sufficient to maintain the vehicle's normal course. This definition is broader than the definition of "collision avoidance" used in a recent Human Factors Workshop session on accident avoidance[1] which states that collision avoidance is: "The above-ordinary skills needed when two road users are in conflict and at least one of them is able to respond to eliminate the situation."

Additional considerations of the broader definition of "collision avoidance" include:

1. The possibility of preventing a collision must be present.

2. The situation and reaction must occur in a compressed time interval.

3. The possible situations include those in which a vehicle may be forced into interaction with a fixed object off the road.

The broader concept of emergency maneuver will be examined here because it is more germane to the proposed curriculum resources than the concept of accident avoidance. This is because we would like to train young drivers for all emergency situations rather than just the on-roadway collision avoidance. The emergency situation demands above average perceptual, psychomotor, decision making, and manipulative abilities to react quickly and accurately under the stress of the compressed time interval implicit in an emergency. The stipulation of the compressed time interval in the definition necessitates the transformation of the relatively simple skills of steering, braking and acceleration used in normal driving into a highly coordinated reaction that requires the additional skills of perception and judgment to be integrated into the response. The skills now become rapid braking, rapid acceleration, and evasive steering -- the nature of which demand a different type of training. This is sometimes considered non-defensive driving because the individual is taught to "steer-out" or "accelerate-out" of certain situations whereas defensive driver training suggests slowing down and avoiding the obstruction. The compressed time interval creates a precipitous situation which involves new skills, and therefore, a different learning experience for the young driver.

The question of why we should train for emergency or advanced driving skills is closely related to the question, "Can we successfully train high school students for these skills?" If it can be shown that successful (i.e., cost-effective) accident and injury-reducing training programs are possible, the reasons why we should implement such a program are straightforward. They would be to reduce fatalities, to reduce the severity and number of injuries, and to reduce dollar amount of property damage. The success, however, of such programs is at best dubious because emergency situations are a relatively low probability event in the driving environment

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[1] *Human Factors Workshop Transportation Research Board, Washington, D.C., January 14, 1970.*

and because without sufficient practice, the driver may not retain adequate knowledge of the skills necessary to perform correctly under the stress of an emergency situation. A close examination of the literature in this area will provide background information on both the feasibility and the cost-effectiveness of emergency programs.

II. REVIEW OF LITERATURE

Over the past few years, several advanced driver education courses have been taught for different student groups. Articles concerning some of the more important of these have found their way into the highway safety literature and are reviewed below. It will be noted that many of these training programs contain very similar maneuvers and exercises aimed at helping students acquire certain skills.

The exercises most frequently used are briefly described as follows:

1) Serpentine exercises: This skill involves zig-zagging through a line of evenly spaced cones in order to develop better special reference and judgment of clearances (and closure).

2) Controlled braking: This involves braking on command and steering around a barrier in the shortest possible distance without loss of control. This is helpful in avoiding an obstacle in the path of a vehicle when the danger of oncoming traffic exists.

3) Evasive maneuver: This skill involves steering around a barrier (right or left) on command at varying speeds up to 40 mph. This is useful in avoiding a collision at high speeds on a freeway.

4) Skid recovery: This entails the ability to prevent or recover from a skid on ice or synthetically created low friction surface.

5) Off-road recovery: The skill of off-road recovery is to regain control of a vehicle that has dropped one or more wheels off the pavement on to the shoulder without shooting across into another lane of traffic.

6) Blowout: This skill involves learning to bring a vehicle to a smooth stop after sudden loss of inflation in either a front or rear tire.

7) Mechanical emergencies handling: This general class of maneuver is aimed at helping the student learn to handle mechanical problems such as brake failure or steering failure in traffic situations.

One of the most widely referred to advanced driver training courses was developed by Whitworth (1972), at the General Motors Proving Grounds in Milford, Michigan. This course was initiated to retrain proving ground drivers to prevent accidents while testing cars. The need for the training program was derived from classic accident causation studies (see Appendix A). In a careful study of this literature, a frequency versus error tabulation resulted in the following driving errors occurring with the greatest frequency:

1) Impaired judgment due to alcohol

2) Misinterpretation of the driving task

3) Improper control of emergency situations

The program consisted of four hours of classroom work in defensive driving and understanding potential hazards. The remaining four hours were behind-the-wheel training exercises on the driving range where six maneuvers were taught and practiced. The maneuvers used were as follows: Serpentine, evasive maneuver, controlled braking, off road recovery, blowout, and skid control.

The GM staff conducted a small, but well controlled, evaluation of their program with 60 subjects who were patrol officers from the Oakland County, Michigan Sheriff's Department. The subjects were divided and matched into two groups of 30. One group received the 8 hour training program and one group remained as a control.

Table 1. Effects of GM training program on accident costs.

	Trained		Untrained	
	Before 1967-1969	After 1969-1971	Before 1967-1969	After 1969-1971
Number of accidents	13	5	11	10
Injuries	?	0	?	2
Lost days	?	0	?	87
Lost wages	?	0	?	$35,000
Vehicle damage cost	?	$1446.50	?	$11247.10
Vehicles totaled	?	0	?	3
Total cost	?	$1446.50	?	$14747.10
Average cost/accident	?	$289	?	$1474.00

Table 1 shows that the trained group exhibited a 50 percent reduction in accidents and an 80 percent reduction in cost per accident as compared to the untrained group.

In a similar study, Quane (1963) put 63 police officers through an advanced driving skills program. Quane used a slightly modified GM course comprised of classroom instruction, serpentine at varying speeds of up to 30 mph, off road recovery at 35 and 40 mph, left-right evasive maneuver at 35 and 40 mph, and a lane change exercise. The experimental design consisted of dividing the population into two groups, giving classroom instruction to both groups, giving range instruction to the experimental group, and then giving both groups a post test followed by more classroom instruction. The results of a one year post instruction study are found in Table 2.

The results are somewhat confusing in that during the first one year period the cost per accident was lower in the control group, but in the second eight month period the reverse was true. The 20 month average cost per accident, however, is lower for the experimental range-trained group. The number of accidents was down 35 percent over the 20 month period. The results might indicate a long term effect of training with good retention and application of learned skills integrated into the driving experience. Quane noted that the experimental group became more aggressive in the serpentine exercise, and made fewer "wrong-way maneuvers" in the left-right evasive test, perhaps indicating some amount of initial learning. Retention of this knowledge can only be assessed after long-term studies which are in progress at the present time. Neither Quane nor Whitworth made any analysis on the statistical significance of their findings.

Another leader in the advanced driver training program has been the Committee on Winter Driving Hazards of the National Safety Council. The N.S.C.'s program has been primarily designed to help the driver cope with skids and slippery surfaces, but some of the GM maneuvers are used on dry pavements such as evasive maneuver, controlled braking, serpentine, and blowout. The ice maneuvers used by N.S.C. are more involved than any other training course (requiring over 25000 square feet of area) and consist of stopping on ice (without skidding), negotiating curves on ice, controlling a skid, and passing on ice. While N.S.C. has reportedly conducted an evaluation on this program, no such study of the accident reducing potential was found in the literature.

The Liberty Mutual Insurance Company is well known for their "Skid School" designed to teach policy holders and fleet drivers to control skids. Their truck driver training program includes training tractor-trailer drivers to handle jack-knifes on ice in which a water flooded "skid pan" is used as a slippery surface rather than ice.

In 1969, Liberty Mutual, in conjunction with Bio-Dynamics Co., reported on the effects of "Fixed Base Simulator vs. Skid Pan Practice in Skid Control Training," in an attempt to evaluate their program. Three treatment groups were used from a population of 58 licensed drivers with ages ranging from 20 to 65 years. The treatment schedule consisted of classroom training and simulator or skid pan training. The simulator was of the mechanical type which has certain drawbacks, including the lack of true choice by the subject, pre-programmed experiences, poor image quality, and only subjective data collection methods.

Table 2. Effects of training on accident costs in a 20 month study with the Maryland Police Department.

0 - 12 month post instruction period

	Control	Experimental
Injuries	0	0
Lost Days	4	2
Number of Accidents	17	13
Lost Wages (Annual Salary-$8,589.00)	$131.76	$65.98
Vehicle Damage Costs	$3,148.79	$2,599.70
Vehicles Totaled	0	1
Cost/Accident (Vehicle Damage Costs Only)	$185.22	$192.88

12 - 20 month post instruction period

	Control	Experimental
Injuries	0	0
Lost Days	4	0
Number of Accidents	6	2
Lost Wages (Annual Salary-$8,589.00)	$131.76	0
Vehicle Damage Costs	$2,395.22	$317.21
Vehicles Totaled	0	0
Cost/Accident (Vehicle Damage Costs Only)	$399.20	$158.60

0 - 20 month post instruction period

	Control	Experimental
Injuries	0	0
Lost Days	8	2
Number of Accidents	23	15
Lost Wages	$263.52	$65.98
Vehicle Damage Costs	$5544.01	$2916.91
Vehicles Totaled	0	1
Cost/Accident (Vehicle Damage Costs Only)	$241.04	$194.46

The treatment schedule for three groups was as follows:

Treatment Group	Classroom Instruction	Simulator Practice	Skid Pan Practice	Immediate Skid Pan Test	3 Month Later Skid Pan Test
1	X	X	No	No	X
2	X	No	X	X	X
3	X	X	No	X	X

The subjects were tested on the skid pan with three different types of skids: (1) four wheel lock and loss of steering, (2) rear wheel lock, and (3) spinout on curve. The authors report that "the results show significant improvement immediately and after three months for the skid pan practice group although only a few of the measures of transfer of training were statistically significant for the simulator practice group." The important point here is that practicing skids on a simulator or the skid pan will help the driver cope with skids, and the retension is at least three months.

Somewhat different results are noted by Williams and O'Neill (1973) in a study in which they analyzed driving (accident) records of race car drivers. All of the drivers were members of the Sports Car Club of America and all had completed at least six hours of in-car, on-range course training in advanced driving techniques sponsored by the club (specifics not available). These race drivers were matched with other drivers from New York, Florida, and Texas on the basis of age, sex, and license type. A comparison of the driving records was conducted.

Table 3 shows the race drivers had significantly more reported crashes, speeding violations, other moving and non-moving violations than the comparison drivers. The authors agree that there are certain problems in drawing any conclusions from the data due to the select, restricted, and perhaps atypical nature of the sample and only limited knowledge of exposure. The fact that the race drivers had significantly more non-moving violations perhaps indicates they are in a more violation- and accident-prone group than the control. (The number of non-moving violations should not be affected by any advanced training program.) The authors suggest caution in instituting an advanced driver education program without studying specific needs.

Peevy (1975) suggests that, "The goal of any emergency instructional program should be to give the student cognitive and manipulative information and skills, experience to reduce the trauma of the emergency, skills related to his general driving patterns, as well as motivation for optimum driving performance (some may prefer defensive driving), and optimum vehicle maintenance procedures." He cautions the acceptance of the GM program *per se* without evaluating local needs because it might not be best suited for young drivers with only limited driving experience. He feels

Table 3. Average numbers of reported crashes and violations per driver by state.

	State	Average Number Per Driver: Race Drivers	Average Number Per Driver: Comparison Drivers	P*
Reported Crashes	Florida	0.28	0.14	0.02
	New York	0.64	0.42	0.001
	Texas	0.58	0.49	0.10
Speeding Violations	Florida	1.28	0.44	0.001
	New York	1.06	0.35	0.001
	Texas	1.63	0.88	0.001
Other Moving Violations	Florida	0.65	0.50	0.10
	New York	0.49	0.38	0.10
	Texas	0.46	0.43	0.10
Non-Moving Violations	Florida	0.22	0.17	0.10
	New York	0.17	0.07	0.002
	Texas	0.22	0.15	0.10

*Conditional binominal test ---- two-tailed probability levels.

(Table taken from Williams and O'Neill (1973).)

the importance of handling mechanical emergencies such as engine stall, brake failure, and steering loss, etc., has been underplayed in the GM and other curricula and these might very well be beneficial to the program.

Zavala and Sugarman (1972) of Calspan Corporation are in the process of developing an accident avoidance training program that emphasizes the physical characteristics of the vehicle and the roadway in their instruction. The primary concern of Calspan's accident avoidance driver training program is threefold:

1. Acquainting the student with vehicle behavior up to the limit of performance at moderate speeds.
2. Acquainting the student with variations in vehicle behavior near the limit of performance as a function of surface condition, loading, tire pressure, tractive effort, etc.
3. Providing the student with driving experience under simulated emergency conditions.

Since this program is still in the developmental stage, it was not possible to obtain a complete description of the maneuvers which will be taught. However, the following outline will provide an idea of the types of driving situations Calspan is researching:

1) Steering and braking avoidance

2) Skid Pad Work -- constant radius cornering, J-turns, fixed and free steering control, under 40 mph (on ice and water)

3) Lane changes (slalom-serpentine) up to 50 mph

4) Effects of load distribution within the vehicle on braking, cornering and skidding maneuvers.

They suggest, as others have (GM, Liberty Mutual, N.S.C.), that if the driver knows what his car can do he will be able to cope with an emergency.

Whittenburg, Pain, McBride, and Amidei (1972), under contract with National Highway Traffic Safety Administration, conducted a controlled study with 17 to 24 year old males in the U.S. Coast Guard station at Cape May. The multi-year task involved (1) establishing base line measurements (biographical as well as driving behavior), (2) developing a driver proficiency test, (3) implementing three types of driver training programs, and (4) followup studies and evaluation of the programs tested.

The background data and pretest phase of the program were implemented through the use of standard personality and attitude tests such as the Mann Inventory, the Thruston Temperament Schedule, the Institute for Educational Development's driver knowledge test and driving tests developed by the authors. These tests were designed to match experimental and control groups for driving exposure and attitudes. This phase of the program appears to be well constructed in terms of quantifying the biographical and preliminary data, but because the sample population is somewhat homogeneous (i.e., all subjects are Coast Guard recruits and perhaps not representative of that age group as a whole), some caution must be exercised in extrapolating the results to other groups.

The training groups consisted of three experimental groups and two control groups with the aforementioned population. One experimental group received classroom and range training (E1), the second received classroom only (E2), and the third range only (E3). There was one control group for E1 (C1) and one for E2 and E3 (C23). The training sessions consisted of 14 hours of classroom instruction including multimedial lessons from the U.S. Air Force standard and remedial courses, and/or 14 hours of range training consisting of simple skills, such as traffic mix. Advanced exercises were also used, including controlled braking, off-road recovery, serpentine and evasive maneuvers on dry and wet pavement, and skid and blowout simulation in later programs.

The follow-up analysis (Whittenburg and Baker, 1974) of the accident involvement histories of the trained and untrained groups indicated differences in the accident frequencies for the groups, with individuals with any training (E1 + E2 + E3), and more than 10,000 miles of driving exposure after graduation of training course experiencing fewer accidents than the untrained control groups (C1 + C23). Here, while 36 percent of the control group experienced one or more accidents, 29 percent of the trained group were involved in an accident -- a 19 percent decrease. In a subgroup of drivers with less than average driving exposure (15-21 months versus a 25 month average), the students receiving only the classroom training subsequently drove better than the students receiving only the range training. Twenty-eight percent of the latter group experienced one or more accidents while 17 percent of the former group were involved in a crash -- a 39 percent decrease.

The authors also examined accident severity differences between the groups. One measure used involved a ratio of total injuries to total accidents. As can be seen in Table 4, the trained groups (i.e., E1 + E2 + E3 and E1 alone) showed dramatically lower proportions in the shorter 8-14 month period after training than did the untrained control groups. This same trend continued through the longer three year period, but with less dramatic difference.

Table 4. Proportion of total injuries to total accidents.

		After 8-14 Months	After 3 Yrs.
No training	C1 + C23	40%	36%
Any training	E1 + E2 + E3	17%	27%
No training	C23		38%
Class or range	E2 + E3		26%
Class only	E2		22%
No training	C1	44%	
Class & range	E1	10%	

When the percent of accidents with one or more injuries was used as the measure variable, the trained groups again appeared to experience less severe accidents, as is indicated in Table 5.

Table 5. Percent of accidents with one or more injuries in the period of 8-14 months after graduation.

Any training	E1 + E2 + E3	16%
No training	C1 + C23	33%
Class + range	E1	10%
No training	C1	35%

However, when reviewing property damage cost, the authors did not find this clear-cut distinction between trained and non-trained individuals, as is shown in Table 6.

Table 6. Average property damage cost associated with all reported accidents in sample.

Group		Cost
Class + Range	E1	$651
Class	E2	$757
Range	E3	$634
Control	C1	$682
Control	C23	$645
Training Average		$673
No Training Average		$665

Finally, Table 7 projects the cost-effectiveness of their accident and injury study from the data collected over the 5 year period 1970-1975.

In the final study reviewed, McCormack (1974) examined the performance of high school seniors on a driving test given to the students. The study was conducted on 500 subjects who were divided into an experimental and a control group. The experimental group received an advanced driver training course consisting of four hours of classroom instruction and six hours of range practice involving the serpentine, the controlled braking, the skid recovery and the evasive exercises developed by Smithson and Whitworth. The test given consisted of the controlled braking, the evasive and the serpentine maneuver. The author could detect no significant changes in either the experimental group's performance on the post-test as contrasted with the pre-test, or in the experimental versus the control group under the post-test conditions.

In summary, the existing literature concerning advanced driver education programs which include training in emergency skills indicates that: (1) there is a set of "consensus maneuvers" which are employed, with some modification, almost universally and (2) there is a lack of well controlled evaluation and conclusive findings concerning the effectiveness of these programs. While two studies indicate a significant decrease in accidents for trained police officers, a third study indicates a much smaller effect for young Coast Guard recruits and a fourth indicates higher accident involvement frequencies for trained race drivers. Thus, there is some indication that accident severity is reduced by this training. It is noted that none of the accident-related studies concern a program involving young inexperienced drivers.

Table 7. Projected reduction in accidents and injuries and resultant savings in property damage as benefit of classroom and range training.

Projected Reduction			Resultant Savings
Number of Individuals Having Accidents			
C average rate	=	.359	
E average rate	=	.289	
Difference	=	.070	
Individuals trained per year	=	4,000	280 per year
Cost of Accidents			
USAF average cost	=	$3,710	
Accident reduction per year	=	280	
Total cost reduction	=	$1,038,800	
Training cost per individual	=	$24.90	
Individuals trained per year	=	4,000	
Training cost per year	=	$99,600	939,200 per year
DOT average cost	=	$2,800	
Accident reduction per year	=	280	
Total cost reduction	=	$784,000	
Cost of Property Damage			
E average reported cost per accident	=	$672	
Accident reduction per year	=	280	$188,160 per year
DOT average cost per accident	=	$500	
Accident reduction per year	=	280	
Total cost reduction	=	$140,000	

Number of Individuals Injured or Killed

C accidents involving injuries	=	33%	
E accidents involving injuries	=	16%	
Difference	=	17%	
Accident reduction per year	=	280	48 per year

Cost of Injuries

USAF average cost	=	2,250	
Injury reduction per year	=	48	$108,000 per year
DOT average cost	=	$11,200	
Injury reduction per year	=	48	
Total cost reduction	=	$537,600	

Cost of Fatalities

USAF average cost	=	$40,000 90,000	
Fatality reduction per year	=	--	--
DOT average cost	=	$2000,700	

(Table taken from Whittenburg, et al. July 1974)

III. DETERMINATION OF SKILLS NEEDED

As indicated in the preceding section, there is a consensus list of maneuvers used in most advanced programs. This list has been derived from multiple sources, ranging from knowledge of accident circumstances to a common sense approach (the latter appears to have been the dominant approach). The authors, noting the Williams and O'Neill caution to look at the local situation and needs, and feeling that it is important to base the suggested program on a more accident-oriented basis, have examined a previous project study involving the critical maneuvers that a young North Carolina driver faces and how these maneuvers are related to emergency situations.

Barry, Roper, & Pitts (1974) reported on "critical maneuvers" of a random sample of North Carolina drivers by reading accident reports of over 1100 cases. The authors determined what proportion of the population were involved in "emergency situations" causing accidents (e.g., skids, blowouts, and brake failure). Table 8 represents their findings.

As noted, nearly 20 percent of the single vehicle and six percent of the multi-vehicle crashes are attributable to emergency situations with little difference being noted between age groups. As shown in Table 9, skidding and brake failure are responsible for the majority of multiple-vehicle emergency situations. The most common cause of crashes resulting from an emergency situation appears to be skidding. In the total sample of 1113 crashes, skidding was a factor in 10.6 percent of all single-vehicle crashes and in 4.2 percent of all multi-vehicle crashes. It is estimated that there are less than 10,000 crashes per year in North Carolina attributable to skidding. The second most important emergency situation involved brake failure, with blowouts a distant third. When the proportion of crashes due to emergency situations is compared between young drivers and middle-aged drivers in both single-vehicle crashes and multi-vehicle crashes no significant differences were evident.

"Non-emergency" critical maneuvers were examined in the same study. Examination of Table 10 indicates that rear end collisions and pulling into the path of an oncoming vehicle are maneuvers that cause a disproportionately higher number of accidents for young people. This suggests an inability of the young driver to cope with these types of situations, which results from either a lack of training or some lack of judgment or closure speed judgment inherent to the inexperienced driver.

In another study, Griffin (1975) determined that 35.7 percent of the fatal accidents in North Carolina in 1973 were caused by a chain of maneuvers that started with one vehicle running off the road. This analysis was conducted by reading each fatal accident report for the year specified. It was further shown that 16-year-old drivers are more likely to be involved in a run-off-road accident than drivers 26 years or older (see Table 11).

Table 8. Emergency situations by age and type of crash.

		No Emergency N	No Emergency %	Emergency N	Emergency %	Total
Single-Vehicle Crashes						
Young drivers		137	(80.6)	33	(19.4)	170
Middle-aged drivers		37	(80.4)	9	(19.6)	46
Total		174		42		216

X^2 (1 d.f.) with Yates Correction = 0.000

		No Emergency N	No Emergency %	Emergency N	Emergency %	Total
Multiple-Vehicle Crashes						
Young drivers	R*	384	(93.9)	25	(6.1)	409
Young drivers	NR*	148	(94.3)	9	(5.7)	157
Middle-aged drivers	R	205	(94.5)	12	(5.5)	217
Middle-aged drivers	NR	103	(90.4)	11	(9.6)	114
Total		840		57		897

X^2 (3 d.f.) = 2.4; p = NS

*R - "Responsible"; NR = "Not Responsible"

Table 9. Types of emergency situations represented in the crash sample.

Type of Crash		Blowout N (%)	Steering Failure N (%)	Brake Failure N (%)	Skidding N (%)	Other N (%)	Total N
Single-Vehicle							
Young		8 (24.2)	1 (3.0)	3 (9.1)	19 (57.6)	2 (6.1)	33
Middle-aged		3 (33.3)	2 (22.2)	0	4 (44.4)	0	9
Multiple-Vehicle							
Young	R*	0	0	6 (24.0)	17 (68.0)	2 (8.0)	25
Young	NR*	0	0	2 (22.2)	7 (77.7)	0	9
Middle	R	0	0	4 (33.3)	8 (66.7)	0	12
Middle	NR	0	0	5 (45.5)	6 (54.5)	0	11
Total		11 (11.1)	3 (3.0)	20 (20.2)	61 (61.6)	4 (4.0)	99

*R = Designated Responsible; NR = Not Designated Responsible

Table 10. Frequency distributions of vehicle maneuvers in two-vehicle crashes, young responsible drivers vs. all others.

Vehicle Maneuver	Young Drivers Responsible N	%	All other Drivers N	%	Total
Pulled into path of oncoming traffic	104	(28.0)	92	(22.0)	196
Rear-end collisions	104	(28.0)	90	(21.5)	194
Improper turns	57	(15.3)	72	(17.2)	129
Ran stop-sign or red light	25	(6.7)	49	(11.7)	74
Failure to yield, improper lane change, over center line	35	(9.4)	48	(11.5)	83
All other maneuvers*	47	(12.6)	68	(16.2)	115
Total	372		419		791

X^2 (5 d.f.) = 14.40; $p < .05$

*This class includes: Passing maneuvers, backing into road, and emergency situations

Table 11. Percent of accidents caused by ran-off-road, for two age groups.

	All Accidents 16 Years	All Accidents 26+ Years	Fatal Accidents 16 Years	Fatal Accidents 26+ Years
Ran-off-road right	14.7	7.0	25.7	16.1
Ran-off-road left	7.8	3.6	23.0	9.3
Ran-off-road straight	0.5	0.4	0.0	0.9
Other accidents	77.0	89.0	51.3	73.7

Thus, there appears to be a set of critical situations, both emergency and "non-emergency," which can lead to accidents for young drivers. It would be hoped, of course, that through additional training and limited exposure to these situations the young driver will be better able to react properly in his subsequent driving.

In an attempt to train young or old drivers to react properly in an emergency situation, certain simulated emergencies could be practiced on an off-road area such as the driving range.

The skidding situation could be approached on a skid pan area built into the existing ranges. Here, on a low-friction wet surface, various skids could be induced and practiced including: (1) front wheel, (2) rear wheel, (3) four wheel, and (4) spin out skids.

The rear end collisions and the collisions caused by one driver pulling into the path of another vehicle might well be approximated by two maneuvers developed by GM: the evasive maneuver, and the controlled braking exercise. These exercises will, in combination with the serpentine, enable the student to learn to judge gap clearances and closure rates. He will learn to avoid a fixed object in the path of his vehicle at moderate speeds, and the transfer of learning to real experiences seems possible because these situations are encountered frequently.

The off-road recovery exercise can train students to fare better when their vehicle leaves the roadway, by giving them practice in bringing the vehicle back on the road surface without overshooting into the next lane. This overshooting is frequently due to the large steering input needed to "jump" the curb, which is 4-6 inches on some rural roads.

In addition to the above exercises, which are often found in an advanced driver education program, a final exercise might involve steering and brake failures. While expensive equipment might be required to closely simulate real brake failure (or steering failure), a close approximation of these conditions could be induced very simply. As revealed by an earlier survey of the existing N.C. range program, most of the automobiles used are equipped with power steering and power brakes. These systems can be "induced to failure" by simply switching off the ignition. Thus, an instructor could switch off the ignition during various segments of a range practice session (i.e., on a straightaway, curve, approaching obstacle in lane, etc.) forcing the student to use correct techniques for recovery, without the assistance of the power brakes or power steering. A simple and inexpensive device can be installed which would enable the instructor to "kill" the ignition from his side of the vehicle.

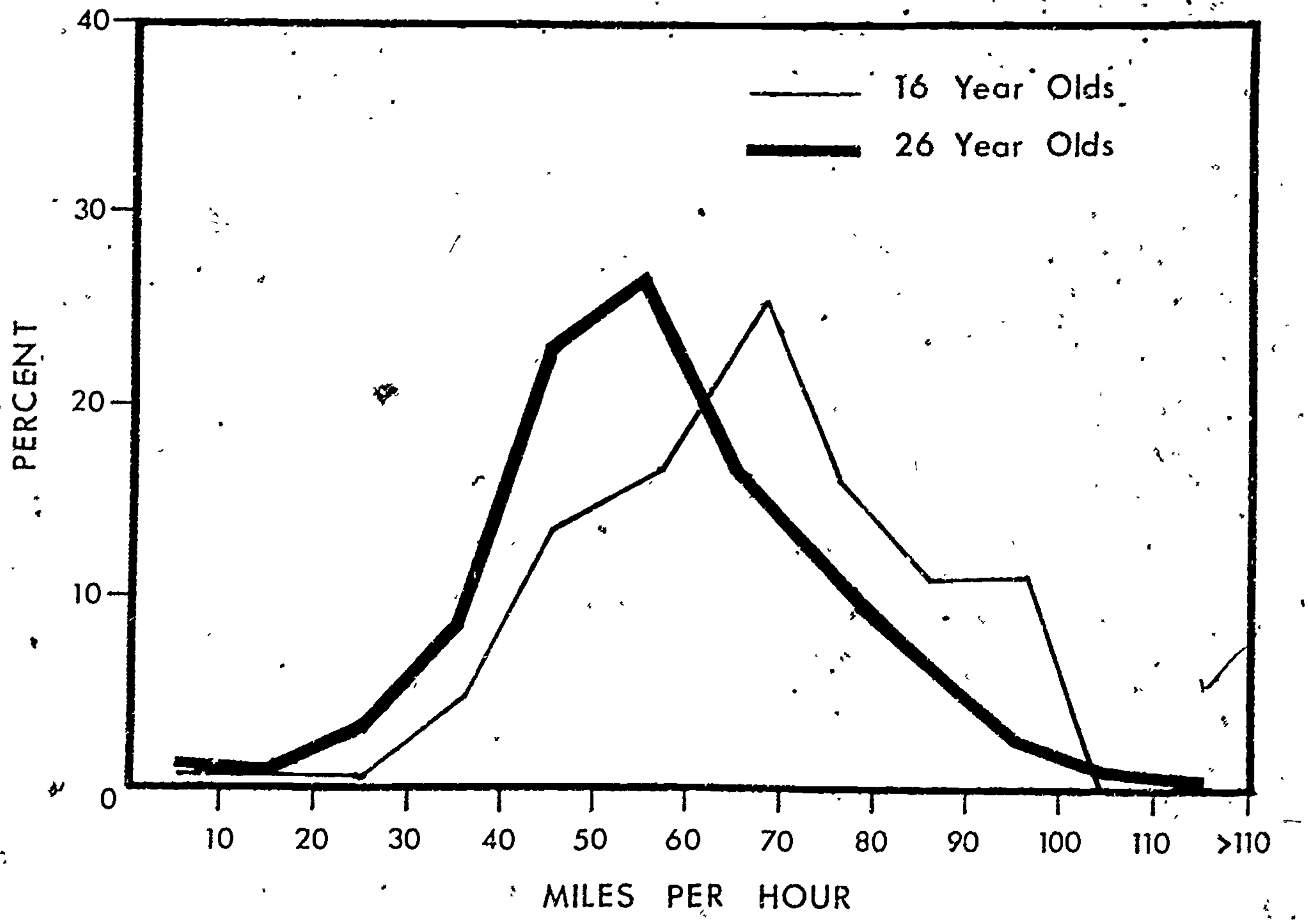
Thus in light of these facts from North Carolina data and the review of the literature, the critical maneuvers which appear to be most useful are off-road recovery, skid control, controlled braking, evasive maneuvers, steering failure, and brake failure situations. These should be considered in creating an emergency or advanced driver training program.

However, we must exercise caution in instituting a program from these results alone. Griffin (1975) also reported on the speed of drivers involved in ran-off-road accidents and found that 16-year-old drivers have a mean and median speed almost 10 mph higher than drivers 26+ years old involved in such accidents (see Table 12). These facts, however, cannot be used directly to analyze the cause of ran-off-road crashes. Other factors, such as type of driving (rural vs. urban, rural road vs. freeway, time of day, driving exposure, peer group pressure, alcohol, etc.) must also be taken into account. An advanced driver training program lasting perhaps a few hours will not prevent the young driver from driving at excessive speeds or under conditions which could turn a normal driving situation into a precipitous one.

A further complication arises in terms of attitude. When giving the student (young or old) only a brief introduction to emergency maneuvering, we may create, in that student, an attitude of false confidence. Many driving instructors report that after the emergency skills lesson some students will exclaim: "Wow! that was fun! When can I practice that again?" The young or inexperienced driver might use these techniques when normal manipulative skills are enough to overcome the problem. This creates more room for error and accident involvement. The student may want to "see what his car can do" and perhaps involve himself in unnecessary danger situations. For example, it is generally believed that the best procedure to follow when your vehicle drops two wheels off the pavement is to slow down and hold the wheel steady while bringing the car to an even stop, but the over-confident driver education student may want to practice his new techniques and perhaps drop two wheels off just to show his peers how "skilled" a driver he really is.

In the study with police officers, Quane (1973) reported higher speeds in the serpentine maneuver in the testing phase with the experimental groups. Does this indicate range trained drivers will become more aggressive? It is hard to extrapolate from the police officer study to high school students, but it does put an air of doubt in the efficacy of such a program. Some driver educators, including Dr. Thomas A. Seals (1974) agree that evasive drills have no place in driver education program for beginners but should be reserved for more experienced drivers as a refresher course. The process of successful accident avoidance entails perceptual, manipulative, psychomotor, and decision-making skills. It seems to be a difficult task for the inexperienced driver to change his cognitive model of reaction from the normal skills to the evasive. This changing might produce more problems than solutions. The experienced driver, however, should have enough exposure to be able to distinguish which model of driving to use. It is the job of the educator to provide a cognitive model for the driver to work with in evaluating each situation separately, as well as to place this model in the right perspective in the course of driver education. The student must be ready to accept this type of skill, or he will use it incorrectly. A well placed program of emergency skills can be an asset to the driver education system, whereas an untimely placement of such a program can be detrimental to the student and the community.

Table 12. Speed distribution of drivers involved in ran-off-road accidents for two age groups.



Feasibility

Although it has been the task of this project to develop an emergency skills curriculum for the 18 multi-vehicle range laboratories in North Carolina, many ranges have already adopted a few of the standard maneuvers and are using them presently (serpentine, controlled braking, evasive). This assures the feasibility of at least those maneuvers being taught. In determining which maneuvers are possible for North Carolina, we must consider space as well as cost and accident reducing potential. These maneuvers, similar to those of GM, can be set up in a minimum amount of space and with only a few pylons readily available to all of our ranges.

The serpentine maneuver, while not directly related to any specific emergency, gives the student practice in timing, gap judgment, and judgment of closure. The student learns to use the "9-3" steering position while running through the exercise at various speeds. The space requirements for this exercise are 24' x 350' and can be easily accommodated in all of the 18 ranges.

The controlled braking exercise is designed to teach the student how to avoid an obstacle in the path of his vehicle while bringing the vehicle to a stop in the shortest possible distance without skidding or locking the brakes. This exercise can be set up on an area 24' x 350' and needs approximately 35 traffic cones to act as a barrier and to form the lanes. The evasive maneuver can be set up in the same way the controlled braking is set up, but it requires a slightly wider lane on the other side of the barriers (36'). The 350 foot length is sufficient and all of the ranges can accommodate this. In the evasive maneuver, the student is directed right or left around a barrier and the speed is up to 35 mph.

With the existing space limitations of the driving ranges only one maneuver might be able to be set up at a time. This should not prove to be much of a problem since the set-up is very simple requiring only the movement of a few traffic cones, and the set up is similar for each maneuver.

The off-road recovery maneuver seems beneficial in light of the number of accidents and fatalities caused by driver error in an off-road situation, but a length of curb 100-250 feet long is required and this might be difficult to find without excessive construction costs or without using public roads. It might be possible, however, to use the edge of the paved driving range in simulation of a soft or gravel shoulder.

The skid pan exercises can be accommodated in terms of space, but do require additional funds for construction and maintenance costs. The minimum skid surface should be 24' x 200' and requiring a 100 foot approach and sufficient dry area around it to prevent accidents. To build a skid pan the area must be resurfaced with a coal tar emulsion (asphalt sealer) such as jenite. This can be applied only to hard surfaces such as asphalt or concrete and some of the ranges are gravel or crushed stone. The resurfacing will cost between $300 - $1500 depending upon area to be paved and labor costs. One gallon of sealing material (@ $1.00/gal.) will cover 100 square feet. The sealer is applied to create a slippery surface when wet. Provisions must be made to flood the skid pan perhaps using a nearby fire hydrant. Car modifications are also suggested such as dual brakes (front and rear), heavy duty shocks, and special tires at the approximate cost of $500 per car. This would not be possible with dealer loan cars because some of the modifications are permanent and would be objectionable to the dealer. However, state cars could be equipped in such a fashion. When the skid pan is not in use and it is dry, it may be used as a normal surface for driving range exercises, but caution must be used during rainy weather.

It is the opinion of numerous educators and researchers that the GM blowout simulator at an initial cost of $350 and the maintenance cost of tires and rims is not cost-effective. As shown earlier, blowouts (Barry, et al., 1973) are not a very likely phenomenon on North Carolina roads. The space needed for such a maneuver to be practiced at 50-60 mph is also too large (600' x 600') to be accommodated by many of the existing ranges. This exercise is very hard on the car and would require that the wheels be alligned and balanced frequently. Dealers are not likely to allow North Carolina educators to use their cars in such a manner.

Mechanical emergencies are easily trained for and are a part of most classroom instruction. Engine stall, brake failure, and steering failure are problems the student should understand and be able to cope with on the road. As discussed previously, these three mechanical problems might be simulated by turning the ignition off while a power assisted car is in motion. This might prove to be an effective and inexpensive aid to the advanced driving resources curriculum.

IV. RECOMMENDATIONS FOR EMERGENCY DRIVING SKILL RESOURCES

The previous material has indicated that there remains a lack of sound data proving the worth of an emergency skills program. However, the N.C. accident statistics indicate that there may be a need for this type of training. Because of these somewhat contrasting findings, and because of the possibility of the adverse effects cited earlier, HSRC strongly recommends a small scale pilot program which can be accurately evaluated. It is noted at this point that DPI and the school systems involved must view this as a trial effort and be aware that the results of the evaluation may not prove the program beneficial. However, until such a program is tried, no conclusions should be drawn. In line with DPI's policy of continually upgrading its program, HSRC recommends that such a trial be initiated.

Based on the accident studies in the literature as well as from North Carolina data, the cost-effectiveness analysis in the previous sections of this report, and the general consensus of researchers in the field, the authors recommend the following maneuvers to be taught on the existing driving ranges in North Carolina. The "set-up" and thus the dimensions required for each specific maneuver can be varied to suit each individual driving range. If the maneuvers are set up with narrower lanes and shorter cue distances, the maneuvers can be run at slower speeds in smaller areas. A speed/distance relationship can be established for each maneuver to normalize the type of training from one range to another. The space requirements shown include an extended area around the course to provide a safety zone.

Traffic cones are required for each maneuver. It is practical to obtain 100 twelve inch traffic cones for approximately $1.75 a piece. The twelve inch size is easier to transport and less expensive than the larger sizes. With 100 cones, several maneuvers can be set up simultaneously. The initial cost for an emergency skills course is approximately $175. The additional cost for each maneuver is included in the following descriptions.

1. Serpentine maneuver--

   Space requirements: 350' x 75'

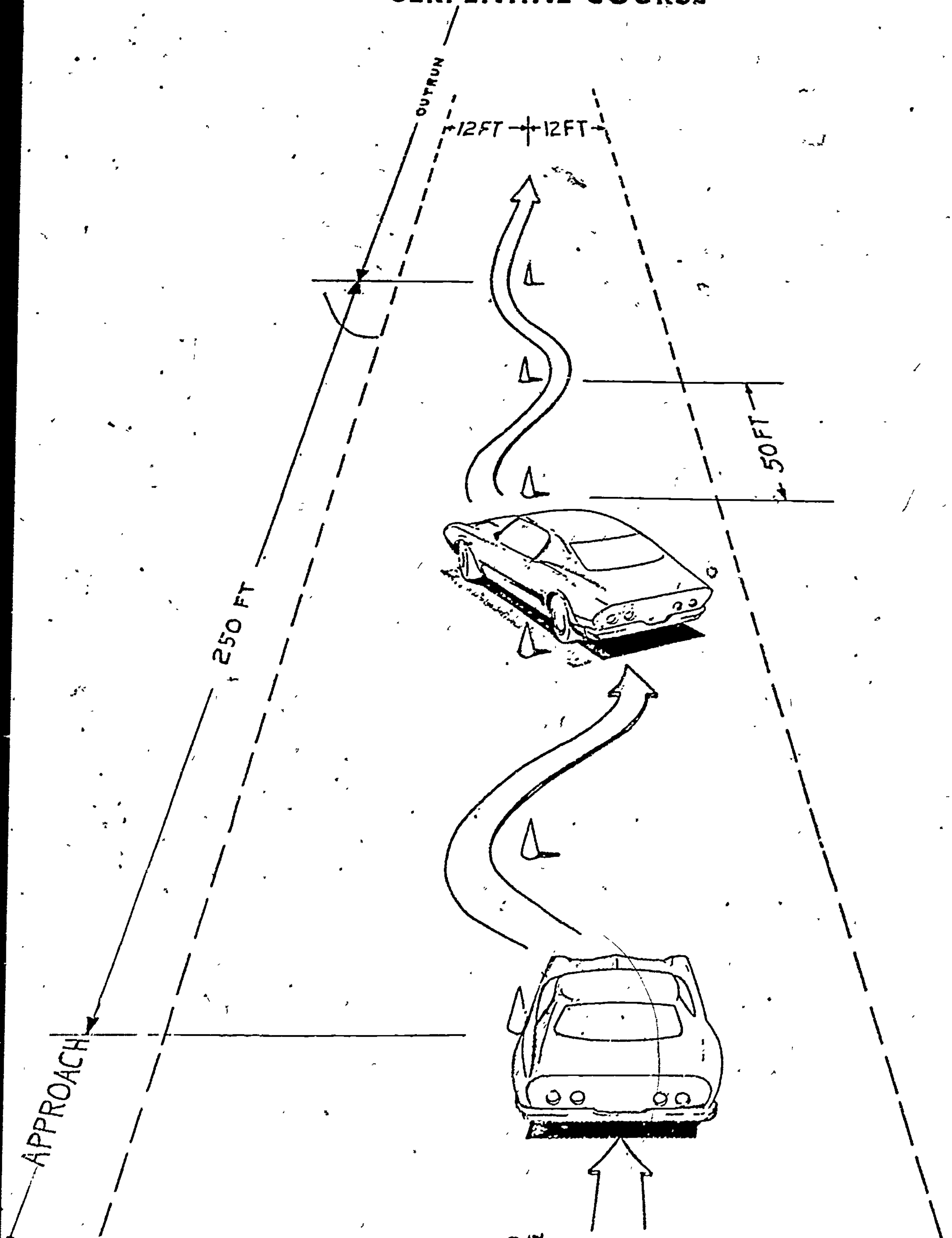
   Materials: 6 traffic cones

   As indicated earlier, the serpentine course, while not related specifically to any emergency maneuver, is helpful in training the student to use proper hand positions, rhythm, and timing in steering the vehicle around a set of traffic cones.

   The cones are set up approximately 50 feet apart along a straight line. The object of this exercise is to approach the first cone at a constant speed and then steer around each successive cone, first to the right and then to the left in a slalom-like manner. The speed is increased on successive trials up to 25 mph (see Figure 1).

Figure 1.

SERPENTINE COURSE



2. Evasive maneuver--

Space requirements: 350' x 100'

Materials: 30 cones

The evasive maneuver is designed to teach the student to avoid an obstruction in the path of his vehicle by steering around it. Because in real driving situations the path on either side of the obstruction might be blocked, a "left" or "right" cue is given verbally 60 feet before the barrier as shown in Figure 2. The timing of this command presents the student with two concepts to master: first, he must decide to turn left or right and then accurately steer the car around the barrier without knocking over any cones. The student is instructed to make several trials at speeds up to 35 mph. The cones are set up as in Figure 2 with an acceleration lane, a barrier, and two exit lanes.

3. Controlled braking--

Space requirements: 350' x 100'

Materials: 40 cones

The controlled braking is similar to the evasive maneuver. The student learns to avoid an obstacle in his path while braking and bringing the vehicle to a complete stop without locking the wheels. A braking cue is given 60 feet before the barrier and the cones are set up with an acceleration lane and an exit lane as shown in Figure 3. The student will perform this maneuver several times at an entering speed of up to 35 mph.

4. Off-road recovery--

Space requirements: 250' x 50'

Materials: 25 cones and curb 100-250 feet long

Cost: variable, depending upon availability of curb

This exercise requires at least 100 feet of curb or dropped shoulder. This could be accommodated by removing part of the dirt shoulder at the edge of the pavement of the range or by building a more permanent 4-inch curb. This maneuver will teach the student to recover from dropping one or more wheels off the pavement without overshooting into the next lane. The exercise is tested at varying speeds up to 50 mph. In most off-road recovery set-ups, the student is instructed to accelerate to a given speed and then is told to drop the wheels off the pavement. To make the exercise more realistic, traffic cones will be used to mark the left-hand edge of the approach lane, and the approach lane will be gradually narrowed until the student is forced off the road. Two recovery modes will then be taught. First, the student will be taught to gradually slow the vehicle to a stop when the shoulder is

Figure 2.

EVASIVE MANEUVER

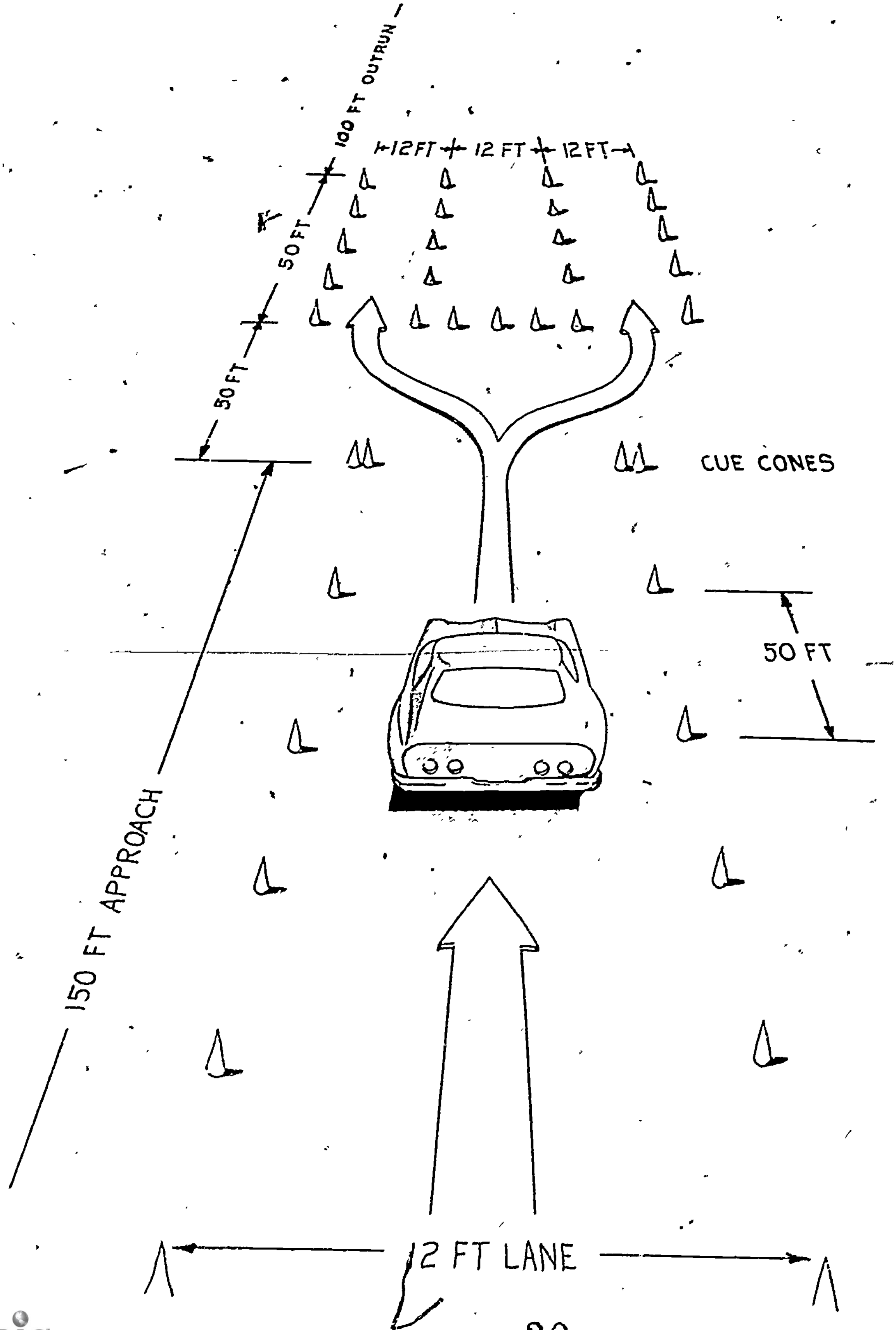


Figure 3.

CONTROLLED BRAKING

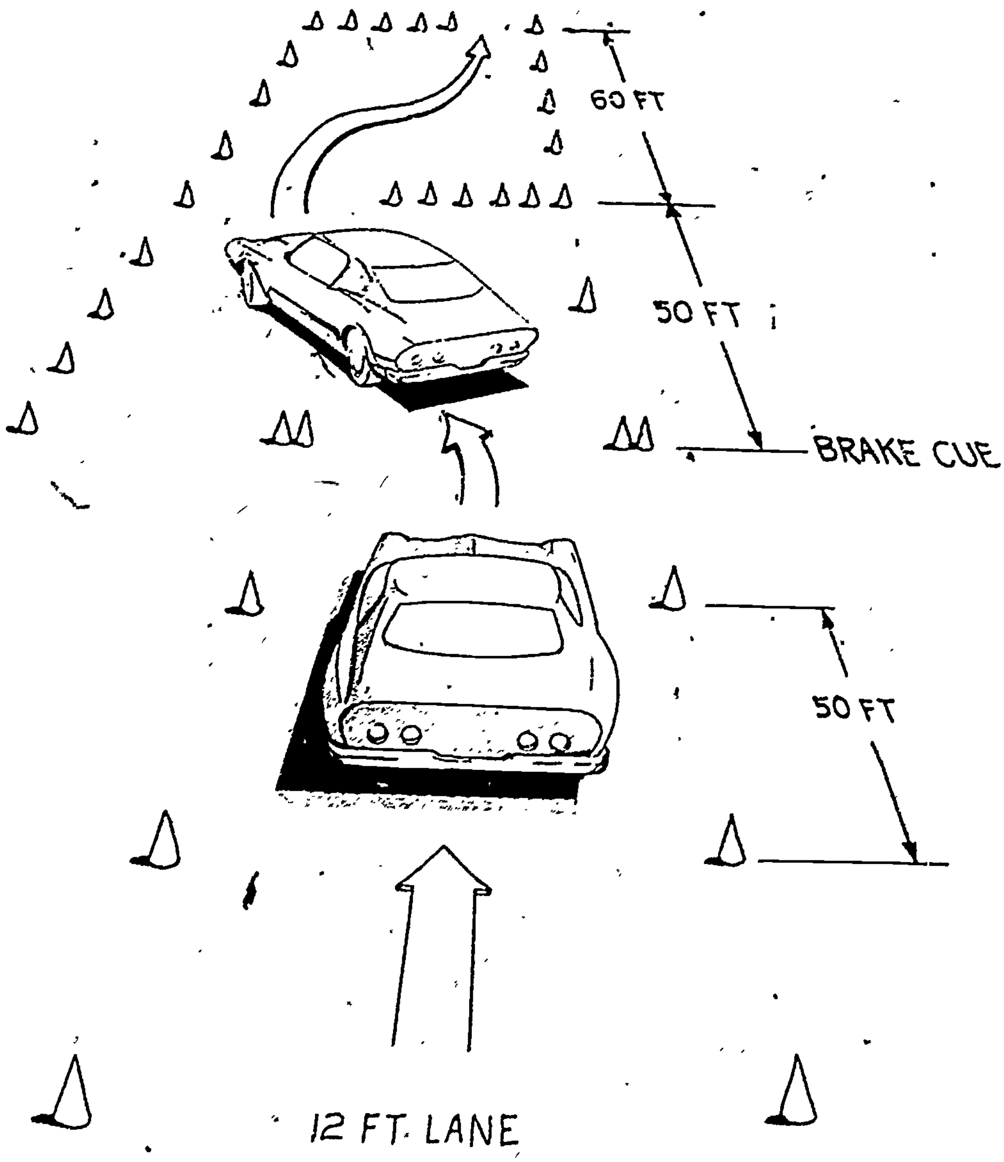
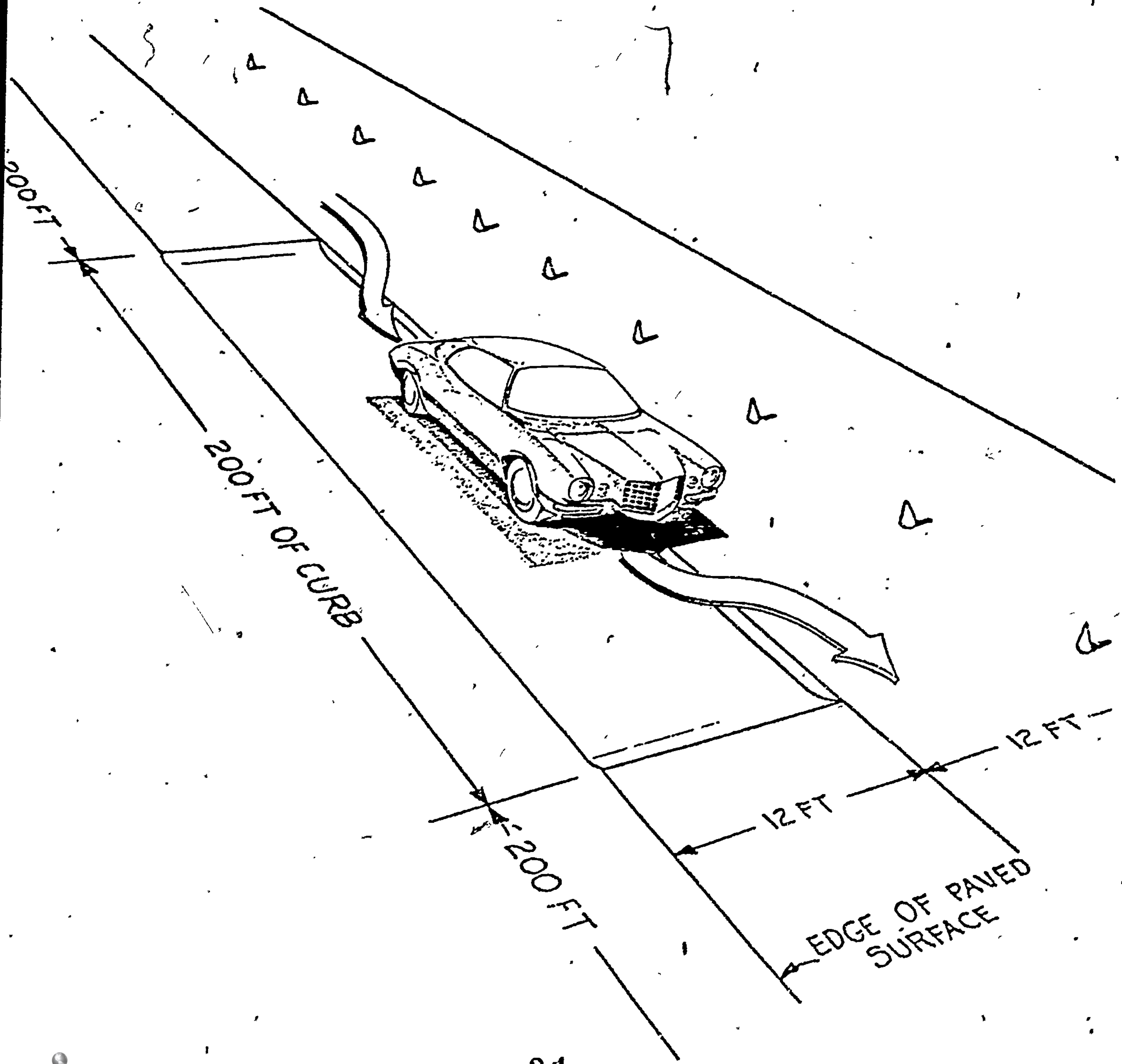


Figure 4.

OFF-ROAD RECOVERY



clear. Second, a barrier (cones) will be placed on the shoulder ahead of the car, forcing the student to quickly steer the car back onto the pavement. The student will be taught to correctly make this recovery without overshooting into the opposing lane. Consideration must be made for realigning and balancing the wheels because the off-road recovery is hard on the vehicle.

5. Skid control--

Space requirements: 250' x 500'

Materials: Skid car, skid pan 50' x 200', 20 traffic cones

Construction costs for skid pan of size 50' x 200':

2 costs of sealer	$100
application of sealer	300-550 depending on labor costs*
water supply	?
	$400-650

*The sealer might be applied by students and instructors saving most of the application cost.

Car modification costs:

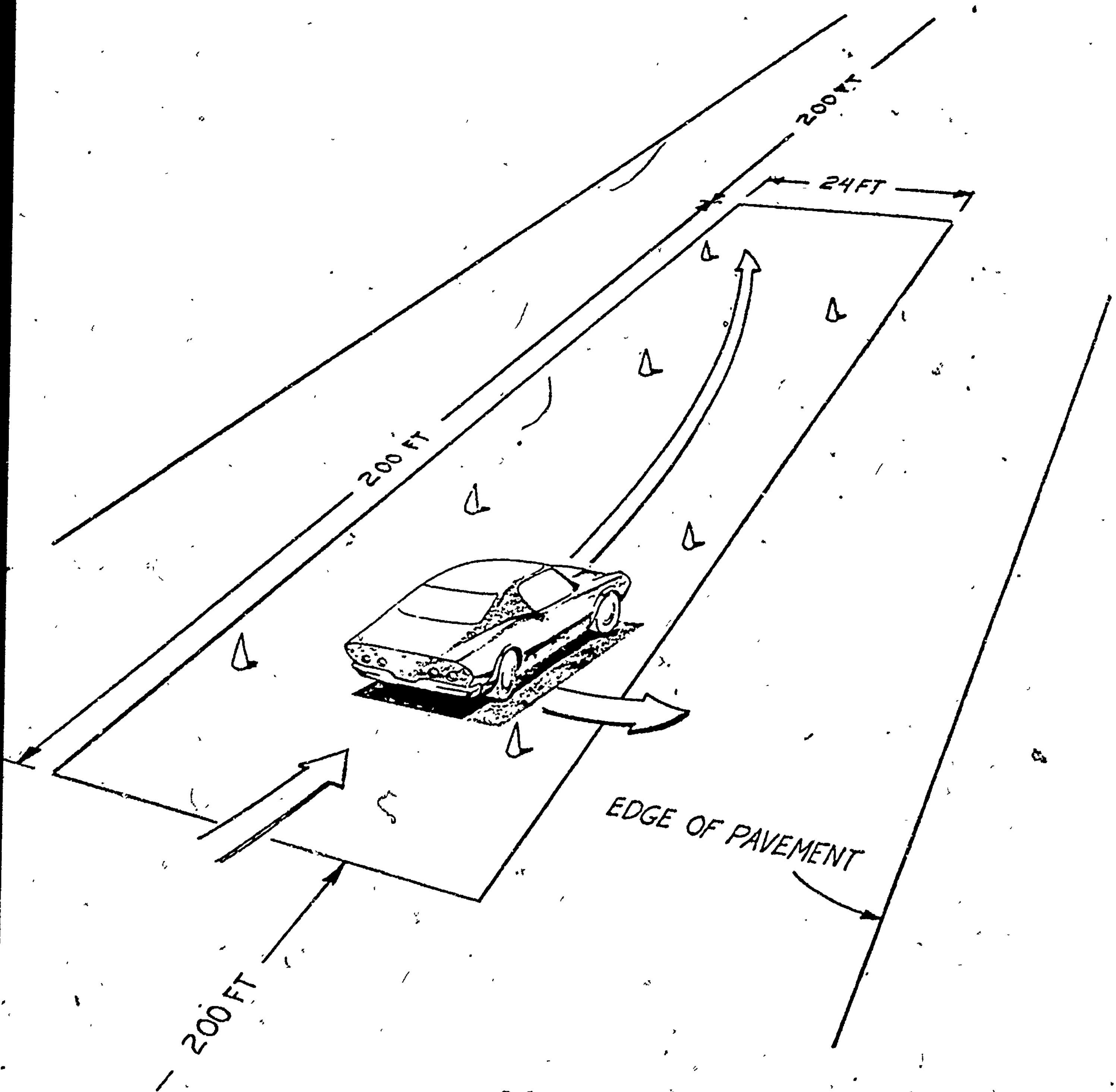
Dual braking system installation	$130
Crash helmets	20
	$150

This exercise gives the student practice in handling skids of various types. This maneuver requires a skid pan of at least 24' x 200' created by resurfacing that area with a coal tar emulsion sealer such as jenite. The car must be equipped with a dual braking system so that the instructor can lock the wheels inducing a skid. If the car is equipped with a braking system that allows the front and rear wheels to be locked independently the student can practice three types of skids -- front, rear, or four-wheel. Otherwise only the four-wheel skid may be used.

The student is instructed to enter the watered down strip and steer his car in a straight line as the instructor applies his brake, causing the skid (see Figure 5). The student will practice the skids at speeds up to 35 mph. At least 100 feet of dry pavement is required on each side of the skid pan to prevent accidents due to loss of control. To prevent accidents when the skid pan is in use, no other cars or persons should be in the area. If the skid pan is large enough (200' x 50'), modified versions (smaller) of the evasive, serpentine and controlled braking exercise can be set up on the skid pan for further advanced training. Advanced skid pan work has been done by Liberty Mutual and N.S.C. as described earlier. Maneuvers taught on the skid pan in other programs are included in Appendix B.

Figure 5.

SKID CONTROL MANEUVER



6. Mechanica emergencies--

Space: optional

Cost: $10.00

The object of this exercise is to acquaint the student with three forms of vehicular system failure -- brakes, steering and engine stall. This exercise is performed on any area of the range while the student is involved in another maneuver. The instructor will switch off the ignition and the student will experience loss of power steering, power brakes, and acceleration. Under these conditions, the student could be taught how to use the emergency brakes to correctly stop the vehicle and could get some feel for the strength needed to steer the vehicle to the roadside. After the student is able to successfully cope with this situation on dry pavement, the same situation could be repeated on the skid pan.

The resources presented here have been developed from a wide variety of sources. However, the similarity between each of the sources suggest a general consensus approach to the problem of training for emergency maneuvers. It has been indicated in this report that an emergency situation is a precipitous one where the driver must react quickly and accurately to prevent a collision. Young drivers are perhaps more susceptible to being involved in emergency situations, but they are probably more easily trained. While the effectiveness of training young drivers remains an unanswered question, it is hoped that an advanced driver training course in emergency maneuvers will reduce the number and severity of accidents in North Carolina. A well conducted evaluation of a pilot program will help provide important information to both state and national driver educators and administrators. Initiating this pilot program for high school students is one part of the recommendations cited in a companion report by Council, et al. (1975). A second follow-up effort at a later date might include initiation of a similar program with more experienced adult drivers as a refresher course or perhaps with a subset of drivers known to have long histories of accidents.

The upgrading of N.C.'s driving range program is an important continuing effort by educators and researchers in the state, and the authors recommend this set of resources as part of that effort.

REFERENCES

American Automobile Association. Driving ranges, routes, and practice areas. In Teaching Driver and Traffic Safety Education. New York: McGraw-Hill, 1965.

American Automobile Association. Meeting emergency driving situations. In How to Drive. Washington, D.C.: Author, 1972.

Barrett, G.V., Alexander, R.A., & Forbes, J.B. Analysis of performance measurement and training requirements for driving decision making in emergency situations (Tech. Rep. 55). Rochester, N.Y.: University of Rochester, Management Research Center, 1973. [NTIS No. PB 220-844]

Barry, P.Z., Pitts, L., & Roper, R.B. An analysis of critical maneuvers in the accidents of young drivers. Chapel Hill: University of North Carolina Highway Safety Research Center, 1974. [processed]

Calspan Corporation. Prospectus accident avoidance training program. Buffalo, N.Y.: Author, 1971.

Central Missouri State College Safety Center. A new kind of driver education: Skidding to safety. Warrensburg: Author, n.d.

Closing the gaps in driver education. Journal of American Insurance, 1972, 48, 29-31.

Duggar, B.C., Young, H.N., Budrose, C.R., & Kanter, E.H. Fixed base simulator versus skid pan practice in skid control training. Washington, D.C.: U.S. Department of Health, Education, and Welfare, Injury Control Research Laboratory, 1969.

Forbes, T.W. Driver knowledge, judgment, and responses in causation and control of skidding. In Proceedings, First International Skid Prevention Conference: Part I (pp. 51-57). Charlottesville: Virginia Council of Highway Investigation and Research, 1959.

General Motors Corporation. The driving environment. Milford, Mich.: Author, n.d.

Griffin, L.I., III, & Leggett, E. Fatal case study analysis. Chapel Hill: University of North Carolina Highway Safety Research Center, in press. [processed]

Highway Users Federation for Safety and Mobility. How to handle driving emergencies: A program for driver and traffic safety education. Washington, D.C.: Author, 1970.

Hoffman, R.G., McLellan, D.R., & Kelly, A.H., Jr. Training drivers for emergencies. Paper presented at General Motors Safety Seminar, Milford Michigan, July 11-12, 1969.

Human Resources Research Organization. Driver education curriculums for secondary schools: User guidelines; safe performance curriculum and pre-driver licensing course. (Hum RRO-FR-ED-74-3). Alexandria, Va.: Author, 1974.

Liberty Mutual Insurance Company. A primer for setting up an emergency driving range. Boston: Author, 1972.

Liberty Mutual Insurance Company. Skid control school. Boston: Author, 1972.

McCormack, D. L. The effects of teaching advanced driving techniques to high school seniors. Master's thesis, Illinois State University, 1974.

McKnight, A.J., & Adams, B.B. Driver education task analysis. Volume 1. Task descriptions. (Hum RRO Tech. Rep. 70-103) Alexandria, Va.: Human Resources Research Organization, 1970. [NTIS No. PB 197-325]

McKnight, A.J., & Adams, B.B. Driver education task analysis. Volume 2. Task analysis methods. (Hum RRO-IR-DI-70-1) Alexandria, Va.: Human Resources Research Organization, 1970. [NTIS No. PB 197-688]

McKnight, A.J., & Hundt, A.G. Driver education task analysis. Volume 4. The development of instructional objectives. (Hum RRP-IR-DI-71-1) Alexandria, Va.: Human Resources Research Organization, 1971. [NTIS No. PB 202-248]

McKnight, A.J., & Hundt, A.G. Driver education task analysis. Volume 3. Instructional objectives. (Hum RRO Tech. Rep. 71-9) Alexandria, Va.: Human Resources Research Organization, 1971. [NTIS No. PB 202-247]

National Safety Council. A winter and emergency driving workbook. Stevens Point, Wis.: Committee on Winter Driving Hazards, 1970.

Overend, R.B. One good skid prevents another. Traffic Safety, 1972, 72, 22-25, 36-38.

Peevy W.D. Emergency driving techniques. Tallahassee, Fla: Florida State University, 1975. [processed]

Quane, R.P. Emergency driving skills; course outline; instructor's manual. Pikesville: Maryland Police Training Commission, 1972.

Quane, R.P. Emergency driving skills feasibility study. Pikesville: Maryland Police Training Commission, Traffic Services Division, 1973.

Quane, W.L. Emergency driving an immediate payoff. Journal of Traffic Safety Education, January 1972, p. 6.

Riley, M.C., & McBride, R.S. Safe performance curriculum for secondary school driver education: Program development, implementation, and technical findings. (HumRRO Tech. Rep. 74-23). Alexandria, Va.: Human Resources Research Organization, September 1974.

Seals, T.A. Evasive drills have no place in driver education for beginners. Journal of Traffic Safety Education, October 1974.

Smithson, F.O., & Whitworth, R.A. Development of an advanced driver education program. (GM 4637). Milford, Mich.: General Motors Proving Ground, 1972.

University of North Carolina Highway Safety Research Center. Single variable tabulations for 1971 and 1972 North Carolina accidents. Chapel Hill: Author, 1973.

University of North Carolina Highway Safety Research Center. Single variable tabulations for 1973 North Carolina accidents. Chapel Hill: Author, 1974.

Whittenburg, J.A., & Baker, G.L. A follow-up evaluation of three driver training programs: 1970-1974. Washington, D.C.: Social Systems Training and Research Inc., 1974.

Whittenburg, J.A., McBride, R.S., Pain, R.F., & Baker, L.B. Driver improvement training and evaluation. (Rep. DOT HS-801 125) Washington, D.C.: The American University, Development Education and Training Research Institute, 1974.

Whittenburg, J.A., Pain, R.F., McBride, R., & Amidei, J. Driver improvement training and evaluation: Initial development. Vol. 1. (Rep. FH-11-7618) Washington, D.C.: The American University, Development Education and Training Research Institute, 1972.

Williams, A.F., & O'Neill, B. On-the-road driving records of licensed race drivers. Washington, D.C.: Insurance Institute for Highway Safety, 1973.

Zavala, A., Sugarman, R.C., & Rice, R.S. Driver training for emergency situations. Paper presented at the Society of Automotive Engineers Automotive Engineering Congress, Detroit, January 10-14, 1972.

APPENDIX A

GENERAL MOTORS ACCIDENT CAUSATION RESEARCH BIBLIOGRAPHY

1. "Accident Facts", National Safety Council, Chicago, Illinois, 1969 edition.

2. Luethje, David S., "The Roles of Alcohol and Drugs in Fatal Single Vehicle Accidents", California Highway Patrol, Sacramento, California, 1967.

3. "A Law is Only the Beginning", Traffic Safety Association of Detroit, Annual Report for 1966.

4. "Wisconsin Coroners Tests on Drivers Under 21 Years of Age", Wisconsin Motor Vehicle Department, Madison, Wisconsin, 1966.

5. Baker, J. Stannard, "Single Vehicle Accidents, A Summary of Findings", published by Automotive Safety Foundation, Washington, D.C., 1968.

6. Bishop, Dr. Richard W., "One Car Accidents and the Young Driver", Florida State University, Tallahassee, Florida, 1962.

7. Forbes, T. W., "Driver Knowledge, Judgement and Response in Causation and Control of Skidding", Paper, First International Skid Prevention Conference 1958.

8. "A Five Year Accident Causation Study", Pennsylvania Turnpike Commission, Harrisburg, Pennsylvania, 1954.

9. Hutchinson, John W., "The Significance and Nature of Vehicle Encroachment on Medians of Divided Highways", University of Illinois, Urbana, Illinois, 1962.

10. Baldwin, David M., U.S. Bureau of Public Roads, "Accident Causes and Countermeasures", Traffic Engineering, V36, March, 1966.

11. "Report of Operation 66", Joint Engineering, Enforcement Project, U.S. Bureau of Public Roads, Washington, D.C., 1966.

12. Robinson, Gordon H., University of Wisconsin, "Accidents and Human Performance", SAE Paper 680555.

13. McFarland, Dr. Ross A., Harvard School of Public Health, "Psychological and Psychiatric Aspects of Highway Safety", Journal of American Medical Association, January, 1957.

14. Penn, Hugh S., "Causes and Characteristics of Single Vehicle Accidents", California Highway Patrol, Sacramento, California, 1965.

15. Ferguson, W. S. and Cook, K. E., "A Theory of Driver Motivation", Virginia Highway Research, Charlottesville, Virginia, 1968.

16. Garwood, F. and Starks, H. J., "Comparison of Methods of Studying Accident Causation", Institution of Municipal Engineers, Proceedings, Convention on Road Accidents, 1965.

17. Borkenstein, Robert F., "A Realistic Approach to Drinking and Driving", National Safety Council's Public Information Conference, 1968.

18. Tillman and Hobbs, "A Study of Accident Prone and Accident Free Drivers", 1949.

Appendix B

Summary of Maneuvers in Other Programs

	Serpentine	Evasive Maneuver	Evasive Wet	Controlled Braking	Off-road Recovery	Emergency Stop	Skid Control (wet)	Skid Control (icy)	Passing (icy)	Blowout	Turning Exercise
Bondurant	X	X				X	X		X		
California Highway Patrol						X	X		X		
Central Missouri State	X	X			X	X		X			
U.S. Coast Guard	X	X	X	X	X	X		X		X	
Florida State	X	X		X	X	X					
General Motors	X	X		X	X		X			X	
Illinois State	X	X		X	X	X	X			X	
Indiana State	X	X			X	X		X			
Liberty Mutual Insurance	X	X			X	X	X			X	
L.A. Police Dept.		X					X				
Maryland Police Dept.	X	X	X	X	X		X		X	X	
Michigan State	X	X		X	X						
National Safety Council	X	X		X		X	X	X		X	
N.C. Highway Patrol	X					X					
Oklahoma State	X	X		X		X	X				
Texas A & M	X	X			X	X	X				
University of Maryland		X			X	X		X		X	
University of Monte Vallo		X			X	X		X		X	
Calspan	X	X	X	X			X	X			X