AORSI-100-VEH Workbook

Overview

This course explains how off-road vehicles behave across different terrains, introducing key physics concepts such as traction, torque, and weight distribution. By studying these principles, students can better predict vehicle behavior and apply safe driving strategies in real-world off-road scenarios.

Learning Objectives

- Understand how terrain affects traction and control.
- Learn about torque management, wheel slip, and center of gravity.
- Apply knowledge to safe maneuvering in real-world scenarios.

Module 1: Vehicle Physics 101 – Motion, Torque, and Friction

Vehicle dynamics are governed by physics. Torque from the engine creates rotational force, while friction between tires and terrain provides grip. Understanding wheel slip, momentum, and resistance helps operators anticipate how vehicles will behave on different surfaces. Students must also learn how acceleration, braking, and steering inputs interact with these forces.

Instructor Guidance: Use visual demonstrations (rolling objects, torque wrenches) to make physics concepts accessible.

Course Design Suggestion: Build a lab where students compare traction by rolling different tires across gravel, mud, and pavement.

Exercise: Define torque and explain how it impacts low-speed crawling in rocks.

Reflection Question: Why is friction both a friend and an obstacle in off-road driving?

Module 2: Terrain Types – Sand, Mud, Rock, Snow, Water

Each terrain type presents unique challenges. Sand demands flotation and low tire pressure, mud requires momentum and wheel speed, rocks demand precise throttle, snow reduces friction, and water crossings involve buoyancy risks. Students should compare strategies for each terrain and learn recovery implications.

Instructor Guidance: Present real-world videos or case studies showing successful vs failed attempts across terrains.

Course Design Suggestion: Assign students to create terrain strategy guides for different vehicles.

Exercise: List two best practices for safely crossing deep mud and shallow water.

Reflection Question: Why does one vehicle perform well in sand but struggle in snow?

Module 3: Weight Transfer & Center of Gravity

Weight distribution affects stability. Vehicles with higher centers of gravity are more prone to tipping, while shifting weight during acceleration, braking, and cornering changes traction at each wheel. Students must understand concepts like pitch, roll, and yaw, and how modifications (roof racks, lifts) affect handling.

Instructor Guidance: Demonstrate with scaled models how weight transfer impacts rollover risk.

Course Design Suggestion: Conduct field exercises where students drive with varying loads to observe handling changes.

Exercise: Identify three factors that increase rollover likelihood in off-road vehicles.

Reflection Question: How does weight distribution affect climbing and descending hills?

Module 4: Managing Traction & Stability

Maintaining traction is central to off-road safety. Wheel slip reduces control, while stability aids like traction control, differential locks, and throttle management improve performance. Students must learn to apply steady inputs, anticipate traction loss, and recover without panic. Understanding how electronic stability systems work is also important.

Instructor Guidance: Show students how traction control systems intervene by demonstrating on loose gravel.

Course Design Suggestion: Provide scenarios where traction aids are disabled, and students must adapt their driving techniques.

Exercise: Compare open differential behavior with locked differential behavior on a steep hill.

Reflection Question: Why is smooth throttle input often more effective than aggressive acceleration off-road?

Final Assessment

Task: Demonstrate practical understanding of vehicle dynamics by driving through varied terrain sections, applying correct physics-based strategies. Students will also complete a short quiz with questions such as:

1. What is torque, and why is it important for off-road driving?

2. How should tire pressure be adjusted for sand driving, and why?

3. What factors contribute to vehicle rollover risk?

4. How do traction control systems improve stability in off-road conditions?

5. Why is momentum management essential in mud and sand?

Duration: 5 hours (with field demos recommended)