Laboratory Work

Topic: Study of Rechargeable Batteries

Objective

- To study the design and principle of operation of rechargeable batteries.
- To become familiar with the main parameters (EMF, internal resistance, capacity).
- To learn how to measure battery characteristics during discharge and charge.

Theoretical Background

1. A **rechargeable battery (accumulator)** is a chemical power source that can be reused multiple times.
2. Main types: lead-acid, nickel-cadmium (Ni-Cd), nickel-metal hydride (Ni-MH), lithium-ion (Li-ion).
3. **Key parameters:**
   - Nominal voltage (V).
   - Capacity (A·h).
   - Internal resistance (Ω).
   - Charge/discharge efficiency.

Formulas:

- Ohm's law for a complete circuit:

$$U = E - I \cdot r \ ,$$

where U — terminal voltage, E — EMF, I — load current, r — internal resistance.

- Battery capacity:

$$C = I \cdot t$$

where I — discharge current, t — discharge time.

Equipment

- Rechargeable battery (e.g., Li-ion 18650 or lead-acid).
- Multimeter.
- Power supply (charger).
- Resistive load (or lamp).
- Connecting wires.

Procedure

1. Measure the open-circuit voltage of the battery.
2. Connect the load, measure the current and terminal voltage.
3. Calculate the internal resistance.

4. Discharge the battery at a constant current, recording the voltage every 5–10 minutes.
5. Plot the graph "U(t)".
6. Calculate the actual capacity of the battery using the formula.
7. Recharge the battery and record the change in voltage over time.

Data Table

Time, min	Voltage, V	Current, A	Charge/Discharge
0			
10			
20			
...			

Control Questions

1. What is the difference between a rechargeable battery and a primary cell?
2. What is internal resistance of a battery and how can it be determined?
3. What factors affect the battery capacity?
4. What are the specific features of lithium-ion battery operation?
5. How does charging a lead-acid battery differ from charging a lithium battery?

Laboratory Work

Topic: Study of the Automobile Alternator

Objective

- To study the principle of operation of an automotive alternator.
- To examine the purpose and design of the alternator and the voltage regulator.
- To measure the output parameters of the alternator under different operating conditions.

Theoretical Background

1. **Automobile alternator** is a power source that converts the mechanical energy of the engine crankshaft into electrical energy.
2. Modern alternators are three-phase synchronous machines with a built-in rectifier (diode bridge).
3. The **voltage regulator** maintains a constant voltage in the vehicle's electrical system (typically 13.5–14.5 V).
4. Main parameters:
    - Rated voltage: 12 V (passenger cars), 24 V (trucks).
    - Alternator current: 40–150 A (depending on the model).
    - Rotor speed: 2000–6000 rpm.

Equipment

- Training stand with an automotive alternator.
- Multimeter or voltmeter and ammeter.
- Load resistor or lamps.
- Mechanical drive source (electric motor).
- Connecting wires.

Procedure

1. Study the alternator design and wiring diagram.
2. Measure the alternator output voltage at no-load (open-circuit).
3. Connect the load and record the current and voltage at different load levels.
4. Vary the rotor speed and observe the change in output voltage.
5. Verify the operation of the voltage regulator (voltage should remain stable when speed changes).
6. Plot the graph of voltage and current versus alternator speed.

Data Table

Rotor speed, rpm	Voltage, V	Load current, A	Notes
1000			
2000			
3000			
4000			

Control Questions

1. What is the principle of operation of an automotive alternator?
2. What is the purpose of the diode bridge in the alternator?
3. How does the voltage regulator work?
4. How does rotor speed affect alternator voltage and current?
5. What are the most common alternator faults?

Laboratory Work

Topic: Study of the Voltage Regulator of a Generator Set

Objective

- To study the purpose and principle of operation of the voltage regulator.
- To examine methods of voltage regulation in an automotive generator set.
- To experimentally determine the performance characteristics of the voltage regulator.

Theoretical Background

1. A **voltage regulator** is a device that maintains the generator voltage within limits required for the proper operation of the vehicle's electrical system and battery charging.
2. Modern voltage regulators are electronic and are often built into the alternator housing.
3. Main functions:
    - Maintaining the onboard network voltage in the range of 13.5–14.5 V.
    - Preventing battery overcharge.
    - Stabilizing operation under changing engine speeds and loads.
4. Principle of operation: the regulator adjusts the generator excitation current depending on the voltage level in the circuit.

Equipment

- Training stand with generator and voltage regulator.
- Multimeter or voltmeter.
- Ammeter.
- Load resistor (lamps).
- Electric motor for driving the generator.

Procedure

1. Study the wiring diagram of the generator with the voltage regulator.
2. Switch on the system and measure the generator voltage at no-load.
3. Connect the load and record the voltage at different load currents.
4. Vary the generator rotor speed and observe the operation of the voltage regulator.
5. Verify that the voltage is stabilized by the regulator within the specified range.
6. Plot the graph of voltage versus rotor speed and load.

Data Table

Rotor speed, rpm	Voltage, V	Load current, A	Notes
1000			
2000			
3000			
4000			

Control Questions

1. What is the purpose of the voltage regulator?
2. How do modern electronic regulators differ from electromechanical ones?
3. How does the voltage regulator stabilize generator voltage?
4. What happens in case of regulator malfunction?
5. What are the typical signs of a faulty voltage regulator?

Laboratory Work

Topic: Study of the Automotive Ignition System

Objective

- To study the purpose and principle of operation of the ignition system.
- To examine the design and functions of the main components (ignition coil, spark plugs, distributor, electronic control unit).
- To experimentally investigate the operation of the ignition system on a training stand.

Theoretical Background

1. The **ignition system** is designed to ignite the air–fuel mixture in the engine cylinders at a specific moment.
2. Main components:
    - Power supply (battery, alternator).
    - **Ignition coil** – steps up the voltage to 20–40 kV.
    - **Spark plug** – produces the spark discharge.
    - **Distributor** (in classical systems) or electronic switch.
    - **Crankshaft and camshaft position sensors** (in modern systems).
3. Types of ignition systems:
    - Contact (mechanical).
    - Contactless (transistor).
    - Electronic with microprocessor control.
4. Key parameters:
    - Spark energy.
    - Breakdown voltage.
    - Ignition advance angle.

Equipment

- Training stand with ignition system.
- Battery.
- Multimeter.
- Oscilloscope (for pulse analysis).
- Spark plugs.

Procedure

1. Study the wiring diagram of the training stand.

2. Check the ignition system operation at idle speed (spark presence).
3. Measure the ignition coil voltage at different engine speeds.
4. Use the oscilloscope to analyze the waveform at the coil output.
5. Determine the ignition advance angle.
6. Compare the operation of contact and contactless systems (if available on the stand).

Data Table

Engine speed, rpm	**Coil voltage, V**	**Secondary voltage, kV**	**Ignition advance angle, °**	**Notes**
1000				
2000				
3000				
4000				

Control Questions

1. What is the purpose of the ignition system?
2. What is the function of the ignition coil?
3. How does a contact ignition system differ from a contactless one?
4. What is the ignition advance angle and how does it affect engine performance?
5. What are the most common ignition system faults?

Laboratory Work

Topic: Study of the Engine Starting System (ICE)

Objective

- To study the design and principle of operation of the internal combustion engine (ICE) starting system.
- To examine the main components of the starting system.
- To investigate the operation of the starter and its interaction with the battery.

Theoretical Background

1. The **starting system** is designed to start the internal combustion engine by cranking it to a speed sufficient for ignition of the air–fuel mixture.
2. Main components of the starting system:
    - Battery (power source).
    - Starter (DC motor).
    - Solenoid (engages the starter and pushes the pinion gear).
    - Ignition (or fuel injection system) – ensures fuel supply and spark.
    - Wiring and ignition switch.
3. **Principle of starter operation:** when the ignition key is turned, voltage from the battery is supplied to the solenoid. The solenoid closes the circuit, engages the pinion gear with the flywheel ring gear, and rotates the engine crankshaft. After the engine starts, the pinion gear disengages automatically.

Equipment

- Training stand with starting system.
- Battery.
- Starter with solenoid.
- Multimeter.
- Ammeter for measuring starting current.

Procedure

1. Study the wiring diagram of the starting system.
2. Connect the battery to the stand and measure its terminal voltage.
3. Switch on the starter and record the starting current and battery terminal voltage.
4. Observe the operation of the solenoid (engagement and return).

5. Measure the current consumption of the starter under different conditions (no-load, engine cranking).
6. Plot the dependence of battery voltage on starter operation time.

Data Table

Operating mode	Battery voltage, V	Starting current, A	Notes
No-load			
Engine start			

Control Questions

1. What is the purpose of the engine starting system?
2. What components does it include?
3. How does the solenoid operate?
4. Why does the battery voltage drop during engine cranking?
5. What are the most common starter faults?

Laboratory Work

Topic: Selection of a Starter for an Internal Combustion Engine

Objective

- To learn how to select a starter according to the specifications of an internal combustion engine (ICE).
- To become familiar with the main parameters of a starter and the factors affecting its selection.
- To calculate the starting current and power of the starter.

Theoretical Background

1. A **starter** is a DC electric motor designed to crank the engine's crankshaft to a speed at which the engine can run on its own.
2. Main engine and starter parameters that affect selection:
   - Engine displacement and power.
   - Maximum engine torque during cold start.
   - On-board voltage (typically 12 V for cars, 24 V for trucks).
   - Starter starting current and power.
3. Formulas for calculation:
   - **Starting power:**

$$P = T \cdot \omega / \eta$$

where T — engine torque, ω — crankshaft angular speed, η— transmission efficiency of the starter.

   - **Starter starting current:**

$$I = P/U$$

where U — on-board voltage.

Equipment and Materials

- Engine data (power, torque, rpm).
- Training stand or tables of starter specifications.
- Calculator or computer for calculations.

Procedure

1. Determine the engine parameters (displacement, power, torque, rpm).
2. Calculate the required starting power of the starter using the formula.
3. Calculate the starter starting current.
4. Compare the calculated values with the starter's rated specifications.
5. Conclude whether the selected starter is suitable for the engine.

Data Table for Calculations

Engine Parameter	**Value**	**Units**
Displacement		cm^3
Power		kW
Torque		N·m
Crankshaft speed		rpm
Starter efficiency (η)		%
Calculated Parameter	**Value**	**Units**
Starting power		W
Starting current		A

Control Questions

1. Which engine parameters affect the selection of a starter?
2. How is the starter starting power calculated?
3. Why is it important to consider the on-board voltage when selecting a starter?
4. What value of starter transmission efficiency is used in calculations?
5. What are the possible consequences of an incorrectly selected starter?

Laboratory Work

Topic: Study of the Automotive Lighting System

Objective

- To study the purpose and design of the automotive lighting system.
- To examine the main components (headlights, lamps, fuses, switches).
- To perform measurements and evaluate the operation of the lighting system in different modes.

Theoretical Background

1. The **automotive lighting system** provides safe driving at night, informs other road users about driver actions, and signals the vehicle's status.
2. Main components:
   - Front headlights (low beam, high beam).
   - Rear lights, brake lights, and turn signals.
   - Interior lighting.
   - Switches, fuses, and relays.
3. Key parameters:
   - Voltage and current of lamps.
   - Lamp power.
   - Luminous flux (for headlights).
4. Modern lighting systems may include:
   - Halogen and LED lamps.
   - Automatic headlights based on ambient light.
   - Daytime Running Lights (DRL).

Equipment

- Training stand with automotive lighting system.
- Battery.
- Multimeter.
- Various types of lamps.
- Connecting wires.

Procedure

1. Study the wiring diagram of the lighting system.
2. Connect the battery to the stand and check its terminal voltage.
3. Turn on different lighting modes (low beam, high beam, brake lights, turn signals) and measure voltage and current in the circuits.

4. Compare the performance of halogen and LED lamps (if available).
5. Check the operation of fuses and relays and evaluate their effect on the system.
6. Conclude about the correct operation of the lighting system.
7.

Data Table

Operating Mode	Voltage, V	Current, A	Power, W	Notes
Low beam headlights				
High beam headlights				
Brake lights				
Turn signals				
Interior lighting				

Control Questions

1. What components are included in an automotive lighting system?
2. How do halogen and LED lamps differ in characteristics?
3. What is the purpose of fuses and relays in the lighting system?
4. What lamp parameters should be considered when replacing a lamp?
5. How can you check the correct operation of the lighting system?

Laboratory Work

Topic: Study of Automotive Control System Sensors

Objective

- To study the purpose and principle of operation of automotive sensors.
- To examine the main types of engine management sensors and their functions.
- To perform measurements and evaluate the operation of sensors on a training stand.

Theoretical Background

1. **Automotive sensors** collect information about the engine and vehicle status and transmit it to the Engine Control Unit (ECU) to ensure optimal operation.
2. Main types of sensors:
    - Crankshaft Position Sensor (CPS).
    - Camshaft Position Sensor (CMP).
    - Engine Coolant Temperature Sensor (ECT).
    - Mass Air Flow Sensor (MAF).
    - Oxygen sensors (Lambda sensor).
    - Throttle position and pressure sensors.
3. Key parameters:
    - Output voltage or resistance.
    - Measurement range.
    - Response time.
4. Modern engine management systems use sensors to control:
    - Fuel injection.
    - Ignition timing.
    - Engine operating modes.

Equipment

- Training stand with engine management system and sensors.
- Multimeter.
- Oscilloscope (for signal analysis).
- Computer with diagnostic software (if available).

Procedure

1. Study the wiring diagram of the sensors.
2. Check the output signals of the sensors at idle engine speed.
3. Change engine operating parameters (temperature, rpm, load) and record sensor signal changes.

4. Use an oscilloscope to analyze the waveform of sensors with variable signals (e.g., CPS).
5. Compare measured values with the sensor's specifications.
6. Conclude on the correct operation of the control system.

Data Table

Sensor	**Parameter**	**Measured Value**	**Units**	**Notes**
Crankshaft Position (CPS)	Voltage/Signal		V	
Camshaft Position (CMP)	Voltage/Signal		V	
Engine Coolant Temp (ECT)	Resistance/Temp		°C	
Mass Air Flow (MAF)	Voltage/Signal		V	
Oxygen Sensor (Lambda)	Voltage		V	

Control Questions

1. What functions do automotive sensors perform?
2. How are the output signals of different sensors measured?
3. What is the purpose of the crankshaft position sensor?
4. Which sensors affect fuel injection and ignition timing?
5. How can a sensor fault be identified by changes in its signal?

Laboratory Work

Topic: Study of the Internal Combustion Engine (ICE) Management System

Objective

- To study the purpose and structure of the ICE management system.
- To examine the operation of the Engine Control Unit (ECU) and its interaction with sensors and actuators.
- To perform measurements and evaluate the operation of the management system on a training stand.

Theoretical Background

1. The **ICE management system** ensures optimal engine performance, fuel efficiency, reduced exhaust emissions, and stable operation under various conditions.
2. Main components of the management system:
    - Engine Control Unit (ECU).
    - Sensors: temperature, pressure, crankshaft and camshaft position, mass air flow, oxygen sensors, etc.
    - Actuators: fuel injectors, ignition system, exhaust gas recirculation (EGR) valves.
3. Main functions:
    - Regulating fuel injection and ignition timing.
    - Monitoring engine operation and signaling malfunctions.
    - Optimizing performance in different operating modes (idle, acceleration, load).

Equipment

- Training stand with ICE management system.
- Multimeter.
- Oscilloscope (for analyzing sensor and actuator signals).
- Computer with diagnostic software.

Procedure

1. Study the wiring diagram of the ICE management system.
2. Check sensor operation at idle engine speed.
3. Measure actuator signals (injectors, ignition coil) under different engine operating modes.
4. Use the oscilloscope to analyze the waveform and response time of sensors and actuators.
5. Compare measured values with the nominal specifications of the ECU.
6. Conclude on the proper operation of the engine management system.

Data Table

System Component	Parameter	Measured Value	Units	Notes
Temperature sensor	Voltage/Signal		V	
Crankshaft position sensor	Voltage/Signal		V	
Fuel injector	Opening time/Current		ms/A	
Ignition coil	Voltage/Signal		V	
Oxygen sensor (Lambda)	Voltage		V	

Control Questions

1. What are the main tasks of the ICE management system?
2. Which sensors are most critical for system operation?
3. How are actuator signals measured?
4. Why is it important to compare actual signals with ECU nominal specifications?
5. What are the most common faults in the engine management system?