



INSTITUTE OF THE
MOTOR INDUSTRY

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EV & HYBRID ▶▶▶

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INTRODUCTION TO ELECTRIC AND HYBRID VEHICLES

£8 +VAT for IMI members, £12 +VAT non-members

| | |
|----------------------------------|---|
| Introduction | <ul style="list-style-type: none"> ▶ Ready Mode and Driver Interface ▶ Reasons for the development of Hybrid and Electric Vehicles |
| Types of electric vehicle | <ul style="list-style-type: none"> ▶ Types of Hybrid and Electric Vehicles ▶ Identification of Hybrid and Electric Vehicles ▶ ASE Classification of Hybrid Vehicles ▶ Battery Electric Vehicle (BEV) ▶ Fuel Cell Electric Vehicle (FCEV) ▶ Series Hybrids ▶ Parallel Hybrid ▶ Series/Parallel hybrid ▶ Series Hybrid System ▶ Parallel Hybrid System ▶ Plug-in-Hybrid drives ▶ Torque support in hybrid systems |

SAFE WORKING PRACTICES, TOOLS AND EQUIPMENT

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|---------------------------------------|---|
| General safety precautions | <ul style="list-style-type: none"> ▶ Risk Assessment ▶ Personal Protective Equipment (PPE) for HV |
| Isolation of electric vehicles | <ul style="list-style-type: none"> ▶ High Voltage Battery Isolation through the Use of a Tester ▶ First Responder Disconnect ▶ Electrical Isolation and Intrinsic Safety of High Voltage Drive Systems ▶ Isolating High Voltage Vehicles (Example: Prius 4 Plugin) ▶ High Voltage Disconnect Devices, Ignition Key and 12V Disconnect Devices ▶ Built In Protection |
| Tools and equipment | <ul style="list-style-type: none"> ▶ Measuring and Test Equipment ▶ Tools for High Voltage ▶ Scan Tools |

ELECTRIC VEHICLE TECHNOLOGY AND COMPONENTS

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| Electric motors | <ul style="list-style-type: none"> ▶ Characteristic parameters ▶ Electric Motors ▶ Motors with squirrel-cage rotor ▶ Motor Position Sensors and Hall Sensors |
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| High voltage components and operation | <ul style="list-style-type: none"> ▶ Formation of a static magnetic field ▶ Identification of HV components ▶ High-Voltage Cable Identification ▶ High-Voltage Cables ▶ High-Voltage Contact Relays ▶ Inverters in hybrid and electric vehicles ▶ DC to DC Conversion ▶ Inverter Cooling ▶ Potential Equalization ▶ Electrical Interlock |
| Electric and Hybrid vehicle construction | <ul style="list-style-type: none"> ▶ Drive Configurations/Hybrid and EV Types ▶ Driving Conditions of Electric Vehicles and Hybrid Electric Vehicles ▶ Driving Modes of Hybrid and Electric Vehicles ▶ Power Split Hybrid System |
| Other vehicle systems | <ul style="list-style-type: none"> ▶ High-voltage air conditioning system (HVAC) ▶ Regenerative Braking |

ELECTRIC VEHICLE BATTERIES AND CHARGING

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|-------------------------|---|
| HV battery types | <ul style="list-style-type: none"> ▶ Construction types of HV Batteries ▶ Interconnection of cells and lifespan of a cell ▶ Battery Hazards ▶ Energy Storage ▶ Hochvolt Batteries ▶ High-Voltage Batteries ▶ Types of Battery Materials ▶ Cylindrical cells ▶ Pouch Cells ▶ Lithium batteries ▶ Fuel cells ▶ Alternative Fuels – Hydrogen Fuel Cells ▶ Nickel-Metal-Hydrid-Akkumulator (NiMH) ▶ Battery Management Systems ▶ High-Voltage Battery Diagnostics ▶ Storage of Various Battery Types ▶ HEV or EV Jump Starting |
| Charging | <ul style="list-style-type: none"> ▶ Charging and Cooling of Batteries ▶ Charging ▶ Types of Charging Connectors |

DIAGNOSING AND TESTING ELECTRIC VEHICLES

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| | <ul style="list-style-type: none"> ▶ Hybrid and Electric Vehicle Diagnostic Strategy ▶ Hybrid and Electric Vehicle Diagnostic Trouble Codes (DTCs) ▶ Electric Motor Diagnostics |
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LIGHT VEHICLES ▶▶▶

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ELECTRICAL

ELECTRICAL COMPONENTS AND MATERIALS

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| | |
|-------------------|--|
| Components | <ul style="list-style-type: none"> ▶ Terminal clamps ▶ Plugs ▶ Screws ▶ Rivets ▶ Crimp connectors ▶ Adhesives ▶ Soldered connections ▶ SMD technology ▶ Printed circuits ▶ Introduction to manufacturing processes |
| Materials | <ul style="list-style-type: none"> ▶ Construction materials ▶ Survey of material groups ▶ Conductor materials ▶ Contact materials ▶ Insulation materials ▶ Resistive materials ▶ Semiconductor materials ▶ Magnetic materials ▶ Auxiliary materials |

ELECTRICAL TERMS AND MEASUREMENTS

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|------------------------------------|---|
| Electric charge | <ul style="list-style-type: none"> ▶ Introduction - Electric charge ▶ Atomic structure |
| Electrical current | <ul style="list-style-type: none"> ▶ Flow of current ▶ Electrical current in metals ▶ Measurement of electric current ▶ Effects of electric current ▶ Types of electric current ▶ Current density |
| Electrical energy and power | <ul style="list-style-type: none"> ▶ Electrical energy ▶ Electrical work ▶ Electric power ▶ Efficiency ▶ Electric heating |
| Voltage | <ul style="list-style-type: none"> ▶ Introduction - Voltage ▶ Voltage source, potential and voltage ▶ Types of voltage generation ▶ Voltage measurement |
| Resistance | <ul style="list-style-type: none"> ▶ The resistor as a component ▶ How electrical resistance arises ▶ Ohm's law ▶ Conductor resistance ▶ Temperature dependence of resistance |

ELECTRICAL TERMS AND MEASUREMENTS (CONTINUED)

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|---------------------------------|--|
| Electricity and magnetic fields | <ul style="list-style-type: none"> ▶ Electric field strength ▶ Electric influence and polarisation ▶ Properties of electric fields ▶ Representation of magnetic fields ▶ Classification of magnetic fields ▶ Current-carrying conductors ▶ Current-carrying coils ▶ Magnetic flux ▶ Magnetomotive force ▶ Magnetic field strength ▶ Magnetic flux density ▶ Current-carrying conductors in a magnetic field ▶ Current-carrying coils in a magnetic field ▶ Current-carrying parallel conductors ▶ Motional induction ▶ Lenz's law ▶ Stationary induction ▶ Eddy currents ▶ Magnetic permeability ▶ Hysteresis loop |
| Measurement and test equipment | <ul style="list-style-type: none"> ▶ Introduction – electric measurement and test equipment |

VEHICLE LIGHTING

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| | <ul style="list-style-type: none"> ▶ Light sources ▶ Ellipsoid headlights ▶ Batteries successfully charged 2 times ▶ Headlamp systems with free-form reflectors and projectors (Super DE) ▶ Adaptive headlamp systems ▶ Headlamp systems with LED technology |
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BATTERIES

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| | <ul style="list-style-type: none"> ▶ Chemical effects of electric current ▶ Conversion of chemical energy into electrical energy ▶ Charging processes for rechargeable batteries |
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STARTER MOTORS

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| | <ul style="list-style-type: none"> ▶ Starter motor basics ▶ Stater Motor |
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ELECTRIC CIRCUITS

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| Parallel and series circuits | <ul style="list-style-type: none"> ▶ Electric circuits ▶ DC circuit ▶ Circuit diagrams and symbols ▶ Laws regarding series circuits ▶ Applications of series circuits ▶ Series resistors ▶ Voltage drops on lines ▶ Laws regarding parallel circuits ▶ Applications of parallel circuits ▶ Mixed circuits ▶ Voltage source load cases ▶ Equivalent circuit of a voltage source ▶ Matching circuits ▶ Voltage source circuits ▶ Voltage divider ▶ Bridge circuit ▶ Indirect resistance measurement ▶ Series connection ▶ Parallel connection |
| Circuit components | <ul style="list-style-type: none"> ▶ Behaviour of a capacitor in DC voltage ▶ Capacitance of a capacitor ▶ Charging and discharging of capacitors ▶ Energy of the charged capacitor ▶ Capacitors in parallel ▶ Capacitors in series ▶ Types of capacitors ▶ Vehicle body as part of the circuit and ground return systems ▶ Automotive Wiring and Connectors, Diagrams and Fuses ▶ Characteristic data of capacitors |

ALTERNATORS AND ALTERNATING CURRENT

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| Alternators | <ul style="list-style-type: none"> ▶ Alternator fundamentals ▶ Components of the generator |
| Alternating current | <ul style="list-style-type: none"> ▶ Period and peak value ▶ Frequency ▶ Phasor representation of sinusoidal quantities ▶ Angular frequency ▶ Generation of alternating voltage ▶ RMS value of sinusoidal alternating waveforms ▶ Phase shift ▶ Active resistances and reactances ▶ Mixed voltages |

MOTORS

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- ▶ Motors with slip-ring rotors
- ▶ Synchronous motor
- ▶ Reluctance motor
- ▶ Permanent magnet stepping motor
- ▶ Hybrid stepping motor
- ▶ Design of a DC motor
- ▶ Universal motors
- ▶ Introduction to servomotors
- ▶ Synchronous servomotor
- ▶ Series-wound motors
- ▶ Shunt-wound motors
- ▶ Compound-wound motors
- ▶ Externally excited DC motors
- ▶ Interpoles and compensation windings
- ▶ DC motors in practice
- ▶ How a DC motor works

NETWORKING AND DIGITAL TECHNOLOGY

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|---------------------------|---|
| Control technology | <ul style="list-style-type: none"> ▶ Signal types in digital and control technology ▶ Basics of control and regulation technology ▶ Control and control technology ▶ Logical operators ▶ Flip-flops ▶ Boolean algebra ▶ Binary number system |
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| CAN – Data bus | <ul style="list-style-type: none"> ▶ Purpose of the CAN Data Bus ▶ Conversion of analogue to digital ▶ PIDs / Live Data ▶ Introduction to network technology |
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ENGINE

ENGINE MECHANICAL, LUBRICATION AND COOLING SYSTEMS

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| Introduction to engines | <ul style="list-style-type: none"> ▶ Components of an engine ▶ Characteristics and Design of Spark Ignition Engines ▶ Spark Ignition Engine Design |
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| Engine operation and components | <ul style="list-style-type: none"> ▶ Connector rods ▶ Installing the crank drive ▶ Crankshaft and crankshaft bearings ▶ Balance shafts and vibration dampers ▶ Pistons and gudgeon pins ▶ Camshafts ▶ Cylinder ▶ Cylinder Head Gasket ▶ Crankcases ▶ Cylinder blocks ▶ Cylinder heads ▶ Cylinder numbering ▶ Timing diagram and firing order of 4-stroke engines ▶ Firing orders ▶ Multi-valve techniques ▶ Valve Clearance ▶ Hydraulic valve backlash adjustment |
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| Lubrications system operation and components | <ul style="list-style-type: none"> ▶ Viscosity Index of Oils ▶ Classification and Stresses of Lubricating Oils ▶ Lubrication ▶ Seals and gaskets ▶ Slide bearing |
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| Cooling system operation and components | <ul style="list-style-type: none"> ▶ Engine cooling systems and cooling techniques ▶ Pump Circulation Cooling ▶ Coolant pump ▶ Liquid Cooling ▶ Expansion material thermostat with double valve ▶ Fan in cooling system ▶ Viscous coupling |
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FUEL, IGNITION, AIR AND EXHAUST SYSTEMS

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| Fuel system operation and components | <ul style="list-style-type: none"> ▶ Petrol Fuels ▶ Diesel Fuels ▶ Basics of fuel injection ▶ Types of fuel injection ▶ Mixture composition ▶ Mixture formation and power control ▶ Fundamentals of mixture formation in gasoline engines |
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| Ignition system operation and components | <ul style="list-style-type: none"> ▶ Spark Plugs ▶ Electrode Gap and Electrodes ▶ Faults and Defects of the Spark Plug ▶ Heat values of the spark plug ▶ Induction law ▶ Self-induction in a DC-circuit ▶ Actual p-V diagram ▶ Replacing the Ignition Coils ▶ Check ignition spark |
|---|---|

FUEL, IGNITION, AIR AND EXHAUST SYSTEMS (CONTINUED)

Air supply and exhaust system operation and components

- ▶ External charging
- ▶ Exhaust gas turbocharger
- ▶ Boost pressure control
- ▶ Intercooling
- ▶ Loader with mechanical drive
- ▶ Variable hydraulic-mechanical valve train
- ▶ Basics of camshaft phasing
- ▶ Variable valve train
- ▶ Fully variable electromechanical valve train
- ▶ Variable hydraulic valve train
- ▶ Variable camshaft control (Vanos)
- ▶ General information about exhaust systems

ENGINE SYSTEM FILTERS

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- ▶ Air Filters
- ▶ Fuel filter
- ▶ Filters
- ▶ Oil Filter
- ▶ Hydraulic filter
- ▶ Screen filter
- ▶ Magnetic Filter
- ▶ Centrifugal filter
- ▶ Cabin Filters
- ▶ Adhesion filter

ENGINE SYSTEM SENSORS AND ACTUATORS

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- ▶ Boost Pressure Sensor
- ▶ Rail Pressure Sensor
- ▶ Classifying sensors
- ▶ Inductive crankshaft sensors
- ▶ Hot-wire air mass meter
- ▶ Pedal Position Sensor
- ▶ Sensors for the measurement of position and displacement
- ▶ Ultrasonic sensor
- ▶ Oil sensor
- ▶ Engine temperature sensor
- ▶ Air temperature sensor
- ▶ Hot-film mass air flow sensor
- ▶ Sensors for measuring temperature
- ▶ Sensors for the measurement of angular displacement
- ▶ Sensors for the measurement of force, pressure and torque
- ▶ Induction law
- ▶ Self-induction in a DC-circuit
- ▶ Proximity switches
- ▶ Solar radiation sensor
- ▶ EGR valve
- ▶ Replace Oxygen Sensor

TRANSMISSION

MANUAL TRANSMISSION SYSTEMS

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Introduction to engines

- ▶ Fundamentals of the Manual Transmission

Clutches

- ▶ Basic principles of the clutch
- ▶ SAC clutch - passenger car diaphragm spring clutch with self-adjusting pressure plate
- ▶ Clutch discs
- ▶ Hydraulic clutch actuation system
- ▶ Dual-disc clutch

Prop shafts, driveshafts and joints

- ▶ Basics of cardan shafts, drive shafts and joints
- ▶ Joint types
- ▶ Constant velocity joints
- ▶ Cardan shafts and drive shafts (axle shafts)
- ▶ Universal joints
- ▶ Axle drive
- ▶ Universal joints

Differentials

- ▶ Active limited slip differential
- ▶ Bevel gear differential
- ▶ Equalizing lock with multi-disc clutch
- ▶ Electromechanically actuated limited slip differential with multiple disc clutch
- ▶ Switchable compensation locks

AUTOMATIC TRANSMISSION SYSTEMS

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- ▶ Torque converter
- ▶ Multi-disc clutch
- ▶ Hydraulic switching valves
- ▶ Planetary gearbox
- ▶ Converter lock-up clutch
- ▶ CVT drive Systems

AIR CON

INTRODUCTION TO AIR CONDITIONING

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- ▶ Purpose of air conditioning
- ▶ Air supply
- ▶ Refrigerant
- ▶ System regulation
- ▶ Air conditioning components

WORKING PRINCIPLES OF AIR CONDITIONING

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|-----------------------------|---|
| Refrigerant | <ul style="list-style-type: none"> ▶ Refrigeration ▶ Refrigerant ▶ Safety measures for work on air conditioning systems |
| Air conditioning components | <ul style="list-style-type: none"> ▶ Refrigerant cycle ▶ Compressor ▶ Magnetic coupling ▶ Condenser ▶ Receiver Drier ▶ Expansion valve ▶ Fixed Orifice Tube ▶ Air conditioning sensors ▶ Air Conditioning Part 1 |

DIAGNOSING AND TESTING AIR CONDITIONING SYSTEMS

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| | <ul style="list-style-type: none"> ▶ When air conditioning is not working properly ▶ Air conditioner out-of-service |
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CHASSIS

STEERING

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|--|---|
| Introduction to steering | <ul style="list-style-type: none"> ▶ Basics, tasks and specifications of steering gears ▶ Steering basics |
| Steering system components and operation | <ul style="list-style-type: none"> ▶ Rack and pinion steering gear (mechanical) ▶ Rack-and-pinion power steering |
| Steering geometry | <ul style="list-style-type: none"> ▶ Wheel offset angle ▶ Roll centre and roll axis ▶ Turntable steering ▶ Track ▶ Camber and spread ▶ Swivel castor radius |

SUSPENSION

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| Introduction to suspension | <ul style="list-style-type: none"> ▶ Basics of wheel suspension ▶ Function of the suspension ▶ Task of the suspension |
| Suspension system components and operation | <ul style="list-style-type: none"> ▶ Steel springs ▶ Basics of Shock Absorbers ▶ Twin-tube Shock Absorbers ▶ Handlebar types ▶ Front axles ▶ Rear axles |

BRAKING

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| Introduction to braking | <ul style="list-style-type: none"> ▶ Mechanically actuated brake |
| Braking system components and operation | <ul style="list-style-type: none"> ▶ Hydraulic brakes ▶ Brake pads ▶ Disc brake ▶ Drum Brake ▶ Brake fluid ▶ Master cylinder ▶ Dynamics of the braked wheel |

WHEELS AND TYRES

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|---|--|
| Introduction to wheels and tyres | <ul style="list-style-type: none"> ▶ The system of wheels and tyres |
| Wheel and tyre components and operation | <ul style="list-style-type: none"> ▶ Wheel mountings ▶ Fundamental aspects of tyres ▶ Tyre dimensions ▶ Tyre labelling ▶ Tyre valves ▶ Braking physics and tyre slip ▶ Kamm's friction circle |

ELECTRONIC CHASSIS CONTROL SYSTEMS

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| | <ul style="list-style-type: none"> ▶ Basics of electronic chassis control systems ▶ Electronic Stability Program (ESP) ▶ Antilock Braking System (ABS) |
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FOUNDATION SKILLS

MEASUREMENTS AND PROPERTIES

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Measurements and measuring tools

- ▶ Outside micrometer
- ▶ Dial gauge
- ▶ Gauges
- ▶ Torque wrench
- ▶ Thread gauge
- ▶ Measuring systems, units, terms
- ▶ Calipers
- ▶ Micrometers
- ▶ Dial gauges, fine pointers, gauge blocks
- ▶ Pneumatic measuring systems
- ▶ Electronic measuring systems

Properties of materials

- ▶ Properties of magnets
- ▶ Tensile test
- ▶ Notched bar impact test
- ▶ Hardness test according to Brinell
- ▶ Hardness test according to Vickers
- ▶ Hardness test according to Rockwell
- ▶ Pressure test
- ▶ Shear test

PHYSICAL QUANTITIES

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- ▶ Mass and force
- ▶ Mechanical work
- ▶ Mechanical energy
- ▶ Mechanical power

THREADS NUTS AND BOLTS

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- ▶ Types of screws and bolts
- ▶ Thread locking
- ▶ Thread inserts
- ▶ Threads