IRSE Professional Examination

SYLLABUS

AUTHORISATION AND REVISIONS
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AIMS AND OBJECTIVES OF THE EXAMINATION SYLLABUS

Notes to Students

This syllabus is intended to give a detailed description of the topics likely to be covered in the examinations, indicating the breadth and the depth of knowledge of topics and skills required. The questions are designed to be answered following the principles and practices of any railway organisation whether heavy rail or rapid transit and wherever in the world it operates. The student is expected to answer in the context of a railway organisation with which they are familiar.

The following notes should act as a guide when reading the syllabus.

AIM

This gives a general overview of what is required for the module and contextualises the Learning Objectives.

LEARNING OBJECTIVES

The learning objectives have been grouped into three sections, the purpose of each section is as follows:

To understand and explain:
This is intended to indicate the depth and breadth of the knowledge required to underpin the following skills. You may be asked to describe or explain topics under this heading in the examination.

To be able to:
A major objective of the examinations is to test the student's operational competence as well as underpinning knowledge. This section indicates the key skills that are expected of the professional railway signalling or communications engineer within the context of the module. You will be expected to demonstrate that you can apply these skills through worked examples and explain your reasoning at each stage.

Related Content (further reading):
Topics within each module are rarely discrete but are interdependent on an understanding of topics that may be dealt with in more detail in other modules.

Other topics, not specifically covered by the other modules but relevant to the subject matter, will also be stated here.

Whilst the topics described in this section are not intended to be core subjects for the module, an understanding of them within the context of the module will demonstrate a wider understanding of the subject matter, and help to give a more professional answer.

Module 1
Safety of Railway Signalling and Communications

AIM

This module is primarily about the organisation and management of people, and the technical activities they undertake. The aim of the module is to ensure that the student demonstrates a professional understanding of the organisation by which the railway signalling and telecommunications system ensures safety.

LEARNING OBJECTIVES

To understand and explain:

- The social, economic, technological and environmental factors that affect the safety of signalling / communications
- Safety management techniques
- Quality control systems and quality management techniques
- Quantified risk assessment
- Rules of operation for the safe working of the railway & general rules relevant to signalling / communications, including working under degraded conditions
- Protection of engineering work sites and track safety
- Protection measures to guard against human failure
- Testing and commissioning
- Accidents and Investigation processes
- The importance of communication to ensure safety
- Relevant legal requirements and standards in force in the student's own country
- Methods of demonstrating safety
- Methods for proving safety & reliability
- The principles of safe engineering for whole life cycle
- The broader obligations of engineers to society

To be able to:

- Compile a safety plan for a relevant activity
- Define safe systems of work
- Ensure appropriate competence of staff (select/train/resource/authorise/motivate/monitor)
- Provide for safe operations during periods of failure of signalling train control / communication systems
- Identify hazards and select or devise suitable control methods
- Ensure that safe identification and configuration of signalling / telecommunications is achieved through safety management of accuracy of scheme design, data preparation, circuit design and, equipment and function numbering.

Related content:

- Prescriptive and performance based specifications
- Signalling / Telecommunications Principles

Module 2
Signalling the Layout

AIM

The primary aim of the module is to ensure that the student can signal a layout for a variety of different traffic patterns and equipment systems in a professional and cost effective manner, taking into account the constraints of the layout and safety requirements. The student also needs to demonstrate a professional understanding of the integration of the equipment and subsystems used to form the complete signalling system. Students may choose between a mainline plan or a rapid transit plan, to best suit their knowledge and experience.

LEARNING OBJECTIVES

To understand and demonstrate:

- The relationship between intensity of traffic, braking characteristics, gradient and the spacing of signals.
- The calculation of time, distance and speed curves
- Headway requirements
- The impact on the signalling design of track layout and line speed

To be able to:

- Demonstrate mathematically or graphically the signalling necessary to meet a given headway
- Interpret signalling principles and operational rules, to show upon a given track plan detail of the signalling required for the safe movement of trains
- Mark upon that plan, the limits of train detection equipment
- Show upon that plan, the normal lie of points
- For the signalling arrangements resulting, allocate all train detection, point and signalling identities
- Prepare aspect sequence or equivalent chart for a given signalling arrangement
- Identify issues of risk associated with signalling and potential mitigating measures

Related content:

- Signalling principles and equipment
- Train detection principles and equipment
- Automatic Warning Systems, Automatic Train Protection & Automatic Train Operation, their uses and limitations
- Points operating principles and equipment

Module 3
Signalling Principles

AIM

The aim of the module is to ensure that the student demonstrates a professional understanding of signalling, from first principles, and can apply this knowledge in a safe, fit for purpose and cost effective manner.

LEARNING OBJECTIVES

To understand and explain:

- Principles of multiple-aspect signalling
- Principles of route and/or speed signalling
- Principles of cab signalling systems
- Principles of signalling interlocking systems
- The principles of control of single line railways. All types of manual and automatic systems
- Principles of absolute and permissive working for double lines & block controls
- Automatic Train Protection principles
- Train Detection principles
- Control Centres
- Transmission/radio based signalling principles
- Moving block principles
- Automatic Train Operation, Automatic Warning Systems, & Automatic Train Supervision- uses and limitations
- Safety Principles
- Principles Testing
- Principles of different types of Level and Grade Crossings used in different environments
- Operational factors: maximisation of line capacity, operating costs
- Safe operation during periods of failure of the signalling and/or train control system
- The impact of electrification systems on signalling principles and layouts

To be able to:

- Prepare interlocking and control tables for given layouts (or parts) or their equivalent where it is not local practice to provide them
- Apply signalling principles to specific applications in a safe and cost effective manner
- Produce graphical information to deduce headway
- Prepare aspect sequence or equivalent chart for a given signalling arrangement

Related content:

- Factors affecting the safety, availability, reliability and maintainability of equipment and systems
- Rules of operation for the safe working of the railway & general rules relevant to signalling, including working under degraded conditions
- Protection measures to guard against human failure
- Whole life costs

Module 4
Communications Principles

AIM

The general aim of the module is to ensure that the student demonstrates a professional understanding of communications in the railway environment, from first principles, and can apply this knowledge in a safe, fit for purpose and cost effective manner.

LEARNING OBJECTIVES

To understand and explain:

- Transmission theory, modulation types, voice and data transmission and security
- Coding theory and methods
- Error detection and recovery, spread spectrum techniques
- Transmission networks, PDH, SDH, Ethernet, DWDM, CWDM
- Telephone networks, operational, business and VoIP
- Communications for computer systems, including TCP/IP principles and protocols
- Computer systems: mainframe, distributed, data storage, backup management
- Radio propagation:point to point and mobile, frequency allocation and regulation, aerials and mast site criteria, , surveys, leaky feeder systems, mobile radio systems GSM-R and Tetra, wireless LAN
- Television: closed circuit, security, data recording, transmission techniques analogue and digital, remote and local control, image recognition techniques.
- Satellites: position monitoring, communication systems, cost minimisation, availability
- Inductive communication: electromagnetic coupling and its uses
- Cables: construction, coaxial, copper twin and quad, optical fibre, cable termination and jointing
- Interference: regulations, theory, immunisation
- Power supplies: main, standby, UPS, earthing and safety, lightning protection, batteries
- Network planning, voice, data and radio

To be able to:

- Apply communications principles to specific applications in a safe and cost effective manner
- Demonstrate the principles involved in the design of safety related telecomms systems
- Develop methods of proving that specific applications meet the required performance specification

Related content:

- National and international regulations: ITU, statutory and others
- Rules of operation for the safe working of the railway & general rules relevant to communications, including working under degraded conditions.
- Whole life costs

Module 5
Signalling and Control Equipment, Applications Engineering

AIM

This module is primarily concerned with equipment at the individual unit, or subsystem level. The student is required to demonstrate a professional understanding of the factors to be considered when applying signalling equipment at all stages in the lifecycle (including research & development), from specification to replacement.

LEARNING OBJECTIVES

To understand and explain:

- The properties, applications and limitations of the following types of equipment:
  - Cables
  - Power supplies
  - Train detection systems and equipment incl. Track Circuits & Axle Counters
  - Remote control systems
  - Point operation and detection
  - Signals
  - Automatic Warning Systems, Automatic Train Protection
  - Interlocking
  - Single line working systems
  - Personnel protection
  - Hot axle box & other defect detectors
  - Level crossings
  - Data and incident recorders
  - Earthing
  - Test equipment & gauges
  - Relays
  - Automatic Train Operation, Automatic Train Supervision / Scheduling
  - Lightning protection
- Environmental factors including, traffic type, tunnel and underground environments
- Train integrity
- Broken rail detection
- Train interference characteristics, immunisation and electromagnetic compatibility
- Communications requirements
- Signal siting/sighting
- Management and passenger information requirements from the signalling and control system
- Testing and Commissioning

To be able to:

- Select signalling equipment for specific applications in a safe, reliable & cost effective manner
- Prepare fault trees for given equipment and subsystems
- Prove and provide for the continued safe and reliable operation of specified equipment or subsystems at all stages of the lifecycle
- Provide for effective handover of equipment and subsystems for maintenance

Related content:

- Quality Assurance and Quality Control
- Type approval & assessment requirements
- Operational requirements
- Servicing, Maintenance and Replacement
- Incident Investigation
- Ergonomics and human factors
- Safety Cases
- Specifications
- Failure Analysis, FMECA
- Installation
- Whole Life Costs

Module 6
Communications Engineering
Applications Engineering

AIM

The general aim of the module is to ensure that the student demonstrates a professional understanding of the factors to be considered when applying communications equipment to a specific railway environment including metro, light rail, main line and subsurface.

LEARNING OBJECTIVES

To understand and explain:

- The properties, applications and limitations of the following types of equipment:
    - Telephone systems including operational and business telephone systems
    - Transmission systems: copper, fibre optic satellite & microwave
    - Radio Systems for railways driver only operation, track to train radio for operation, token systems, wireless LAN
    - Safety critical communications, land-based and mobile, incl. public networks
    - Public address (station and long line) and customer information systems
    - Use of the internet for real time and interactive customer information
    - Electrification power control: transmission and security
    - Clock Systems
    - CCTV Systems
    - Communications systems for underground and sub surface railways
    - Safety and functional earthing, lightning and surge protection systems
    - Network management, intelligent infrastructure and remote condition monitoring
- Testing and Commissioning, roles and responsibilities, test strategy, test plans, risk management, competence and independence

To be able to:

- Apply communications equipment to specific applications in a safe and cost effective manner
- Prepare a functional specification
- Create an integrated testing strategy for a safety related communications system

Related content:

- Safety cases
- Specifications
- Type approval and assessment requirements
- Quality assurance and quality control
- Failure analysis
- Operational requirements
- Servicing, maintenance and replacement
- Immunisation and electro-magnetic compatibility
- Ergonomics, disability and discrimination considerations
- Whole life costs

Module 7
Systems, Management and Engineering

AIM

The aim of this module is to ensure that the student has a systems engineering perspective of the railway signalling, control & communications system and can provide for the integration of many subsystems and diverse equipment in a professional manner.

LEARNING OBJECTIVES

To understand and explain:

- Systems engineering
- Design and operational considerations for failure conditions/ restoration of service
- Human performance and interface issues
- Maintenance and installation practices
- General phases of a signalling or communications project.
- Environmental factors
- Interactions with other disciplines in the railway system
- Environmental impact
- Whole-life cost issues
- The different types of specification and their appropriateness
- Requirements engineering

To be able to:

- Prepare a specification
- Configure systems to achieve safety, reliability and economy
- Calculate the reliability and availability of a system
- Use safety analysis techniques including fault trees, event trees and failure mode effect & criticality analysis
- Apply software verification and validation techniques
- Provide for electromagnetic immunity
- Conduct a quantified risk assessment

Related Content:

- Management and control procedures during the design and development phase
- Fail safe systems and categories of failures
- Control systems theory
- Key areas for system quality and safety checks
- The advantages and limitations of new technology
- Human factors and human error
- Hazard, risk & qualified risk assessment, identification and analysis techniques
- Configuration control
- Testing, its purpose and organisation
- Relevant standards