Question 1

Signalling and telecommunication cables require different types of electrical and mechanical protection depending on their application and their function. Describe the hazards associated with the cables listed below and provide mitigations to overcome the resultant risks:

a) A signal or telephone tail cable running on ballast.
b) A tail cable to an axle counter head.
c) A multi-core signalling or telecoms cable running externally between two equipment rooms.
d) A multi-core signalling or telecoms cable running within a building from an equipment room to a control room. [16 marks]

Large diameter cables can be expensive, difficult to install and are vulnerable to theft. What engineering solutions can be implemented to overcome these problems? [9 marks]

Question 2

Using a clearly labelled diagram, provide an overview of a point operating mechanism. Your answer should include the means of drive, locking and detection, including details of locking and detection for both the open and closed switches. State any assumptions you have made about the operation and use of the mechanism. [15 marks]

For your chosen point mechanism, provide a specification for its initial set up, testing and subsequent maintenance. [10 marks]
Question 3

Following an incident where a train has passed a signal at danger, a driver has alleged that an incorrect aspect sequence was displayed. All the signals in the area are controlled by a processor based interlocking.

Describe how you would carry out an investigation into the incident including the sources of information you would use. [13 marks]

Discuss the possible causes of the incident where:

i) the investigation reveals that the aspect sequence was indeed incorrectly shown.

ii) the investigation cannot identify a fault with the signalling system. [12 marks]

Question 4

Describe a system to manage the competence of engineers that test signalling or telecommunication equipment. Your answer should include:

• The means of demonstrating competence 
• How competence can be developed 
• The various levels required for the engineers 
• How the system is monitored [15 marks]

Test engineers are required to undertake the testing of equipment to commission it into service, or as part of routine maintenance when the equipment is in daily service. Outline the different competence requirements of these two roles. [10 marks]

Question 5

A new electronic interlocking system has a boundary interface with an existing relay interlocking across a busy junction area. Using a diagram, describe the hazards, risks and mitigations associated with such an arrangement. Your answer should include specific measures you would recommend in the design to reduce the risks. [15 marks]

Provide an outline test plan detailing the approach you would take to ensure that the issues you have highlighted are appropriately tested. Your answer should include details of both off-site and on-site testing. [10 marks]

Paper continues on next page
Question 6

An existing level crossing is to be replaced. The level crossing is on a double track secondary mainline with a line speed of 80km/h. The road is lightly used and serves a light industrial site.

Two options are being proposed;

i) an automatic open crossing using road traffic light signals only, OR

ii) an automatic crossing with barriers which block off half the road.

Using diagrams, compare the two options. Your answer should include:

a) details of the interface to the existing signalling system [10 marks]

b) any hazards and the risks arising [5 marks]

c) the information and equipment to be provided for road users. [10 marks]

Question 7

Describe how verification and validation techniques differ for the following types of signalling systems:

i) A completely new signalling system,

ii) An alteration to an existing signalling system that introduces new functionality,

iii) A component replacement with a functionally equivalent component e.g. new track circuit relay, cable replacement, battery charger replacement.

Your answer should include techniques that will ensure the commissioning into operational service is carried out safely and efficiently. You should also include a description of the purpose of the techniques, what they are expected to achieve, and why they are relevant. [25 marks]

Question 8

Describe with the aid of sketches, the electrical principles and physical construction details of a relay, either for use on a dc electrified railway OR an ac electrified railway.

For the relay of your choice explain the properties that make the relay suitable for the environment into which it is to be deployed. [20 marks]

What operational limitations are imposed upon the relay by the environment into which it will be deployed? [5 marks]

Paper continues on next page
**Question 9**

A dc track circuit is provided with an additional resistance at the relay end, connected in series with the relay coil. The characteristics of the track circuit are as follows:

- Feed transformer rectifier output: 5.0 Volt
- Relay coil resistance: 9.0 Ohm
- Relay pickup current: 40.0 mA
- Ballast resistance: 2.5 Ohm km
- Length of track circuit: 600 m

a) Draw the circuit and equivalent circuit and calculate the value of the additional relay end resistance that will ensure a minimum rail to rail voltage of 0.7V when the track circuit is clear of trains. [6 marks]

b) Calculate the value of the feed resistance that will ensure reliable operation of this track circuit. [6 marks]

c) Calculate the drop shunt when the feed and relay end resistances have the values you have calculated. [10 marks]

Explain briefly the advantage of the additional relay end resistance. [3 marks]

**Question 10**

During the development phase of a major re-signalling scheme it has become necessary to make some choices regarding the type of signaller’s interface to be deployed.

Describe the ergonomic considerations of designing such a signaller’s interface to a signalling system that includes a number of automatic and manually controlled level crossings. State any assumptions that you make in respect of how the signalling system and level crossings are operated. [20 marks]

How could the level crossing types affect signaller workload and what might the system limitations be? [5 marks]

End of paper.