Question 1

a) Draw the physical representation of a typical DC track circuit type with which you are familiar making sure that you include the electrical parameters and an equivalent circuit.  

b) Using your typical track circuit electrical parameters show mathematically how the relay reliably picks and drops.  

c) Describe an electrical failure mode caused by ballast conditions where the track circuit would show occupied when clear. Show the effect of the ballast conditions on your original calculations. 

Question 2

a) Describe, with the aid of sketches, the electrical principles and physical construction details of a signalling relay, either for use on a DC electrified railway OR an ac electrified railway. For the relay you have described, explain the properties that make the relay suitable for the environment into which it is to be deployed. 

b) A relay has been deployed onto an operational railway but is experiencing premature contact failure. What operational and environmental characteristics might lead to this?
Question 3

As part of a re-signalling project, the signalling power supply system is due to be upgraded to an automatic reconfigurable supply.

a) Describe, with diagrams, the main features of an automatic reconfigurable power supply system including the system safety and economics. [15 marks]

b) Explain how the design would take account of the following types of load:

i. Signals
ii. Train Detection – Axle counters
iii. Track circuits
iv. Switches and Crossings using point machines
v. Level crossings
vi. Remote interlocking (computer based) [10 marks]

Question 4

A railway administration is carrying out a re-signalling and track remodelling project whereby the current four-track railway system is being upgraded as follows:

• Operating Panel replaced by VDU system;
• Track circuits replaced with axle counters;
• New lineside power distribution;
• Introduction of higher speed junctions with longer turnouts;
• Point machines changed to accommodate longer turnouts; and
• New LED type signals, located in similar positions to existing.

It is not possible to remodel the track layout at the same time as the signalling is renewed so it will be required to stage the track works either before or after the signalling renewal takes place. The railway needs to keep the junctions operational throughout.

a) Detail a methodology for the Signalling or Telecommunications stage works required and describe the sequencing of the works for both of the following scenarios:

i. if the track layout is remodelled before the main signalling [10 marks]
ii. if the track layout is remodelled after the main signalling [10 marks]

b) What operational issues and design features would you consider when choosing which of these two scenarios is used for the project? What additional design would be required to support the main commissioning if the track remodelling is carried out after the signalling? [5 marks]
Question 5

a) Describe a system which provides train protection for a Stop signal or limit of movement authority. Using a diagram, clearly describe each of the following:

i. How the speed of a train approaching a Stop signal or a limit of movement authority is monitored and controlled;
ii. How a train is prevented from ignoring a signal displaying a Stop aspect or a limit of movement authority; and
iii. The necessary interfaces to the signalling system including the interlocking and control system. [15 marks]

b) An incident has occurred where a train has passed a red signal or a limit of movement authority and has continued beyond the safe overrun distance in to an unprotected area of railway. Using a fault tree, outline the possible causes of such an event. [10 marks]

Question 6

a) Describe, with the aid of sketches, the key features of an automatic level crossing, i.e. where the train approaching activates the warning equipment at the crossing. Assume that the crossing is on a double track and is equipped with flashing road lights, barriers and an audible warning for pedestrians. Explain the equipment configuration and sequence of operation. Describe suitable timings for equipment operation and explain how this contributes toward the safety of the system. [15 marks]

b) Compare and contrast the benefits to road users of the crossing if it is initiated by:

i. fixed train detection point.
ii. an adaptive strike in point. [5 marks]

c) How might an obstacle detection system be integrated into the automatic crossing you have described? [5 marks]

Question 7

Signals being passed at danger still pose a significant risk to railway operation.

a) Describe a methodology that can be employed during scheme design to evaluate the risk of a signal being passed at danger. You should comment on opportunities that could be taken during scheme design to manage the consequences of signals being passed at danger. [15 marks]

b) An existing signal has a history of being passed at danger. What steps could be taken to reduce the risk of this signal being passed at danger again? [5 marks]

c) What external influences might lead to a train passing a signal at danger? [5 marks]

Paper continues on next page
**Question 8**

A transmission-based (in-cab) signalling system is to be introduced onto a busy main line that is currently using a fixed lineside signalling system. Existing rolling stock will be fitted with the transmission-based signalling system in phases with some stock not being fitted before implementation of the first phase of the scheme.

a) Describe how the roll out of this transmission-based signalling system might be achieved, including compatibility with all rolling stock and the technical and operational considerations required when interfacing the two systems. [10 marks]

b) Describe the hazards introduced by any temporary interfaces between the two systems and the possible means to mitigate the resulting risk. [10 marks]

c) What on-track apparatus would need special consideration with respect to physical placement? How would this be managed? [5 marks]

**Question 9**

Signalling and telecommunication cables require different types of electrical and mechanical protection depending on their application and their function.

a) Describe the construction features of the cables listed below and how they overcome the environmental conditions to which they are exposed:

i. A signal or telephone tail cable running across the track.
ii. A tail cable to a track circuit termination or axle counter wheel sensor.
iii. A multi-core signalling or telecoms cable running along the trackside externally between two buildings.
iv. A multi-core signalling or telecoms cable running inside a building from an equipment room to a control room.
v. A lineside high voltage power cable. [15 marks]

Large diameter cables can be expensive and difficult to manoeuvre and are vulnerable to theft.

b) What engineering solutions can be implemented to remove or reduce these issues? [10 marks]

Paper continues on next page
Question 10

A railway maintenance department is proposing to change their electric point mechanisms from one type to another. The new machine’s internal wiring and functionality is different to the old one.

a) Describe what considerations the maintainer would have to make with regards to compatibility of the new point machines with:

i. Existing interlocking design
ii. Existing Control System
iii. Existing permanent way
iv. Fault finding and maintenance procedures

[16 marks]

b) Describe a testing regime that would ensure the new points could be safely entered into service taking into account any alterations required to the infrastructure.

[9 marks]

End of paper