Aim
This unit aims to develop learners’ understanding of the principles and characteristics of telecommunications systems.

Unit abstract
This unit covers the principles of communicating at a distance. It considers the three elements required for the transfer of information, ie the source (transmitter), channel (link) and sink (receiver).
The use of practical/imperfect channels and the presence of interference in the form of electrical noise are considered. The bandwidth of typical signals is also covered with respect to the available portions of the complete electromagnetic spectrum. The unit also covers the requirement for the modulation of information and multiplexing techniques in both analogue and digital format. The characteristics of telecommunications traffic and queuing theory are considered, along with the mathematical tools and computer modelling systems required for analysis and methods of controlling congestion.

Learning outcomes
On successful completion of this unit a learner will:
1 Understand the requirements of communication systems
2 Understand communication channels and their characteristics
3 Understand modulation and multiplexing techniques used for analogue and digital signals
4 Understand the characteristics of communications traffic.
Unit content

1. Understand the requirements of communication systems

Elements of analogue and digital communication systems: the transmitter (information source), the channel and the receiver eg wired and wireless systems; simplex, duplex and half-duplex methods

Characteristics of electro-magnetic waves: frequency (f), wavelength (λ) and velocity (v) and their interrelationship; the electro-magnetic spectrum and frequency/wavelength allocations

Signal spectra: time and frequency domains; fundamental and harmonic frequencies; complex waveforms; digital signals eg unipolar, bipolar, return-to-zero (RTZ), non-return-to-zero (NRZ)

Logarithmic relationships: the need for logarithmic representation; the Decibel and its common derivatives (dBm, dBW and dBR) and typical applications including link budgets

2. Understand communication channels and their characteristics

Sources and effects of noise: sources eg internal/external, natural/man-made; types eg Johnson, Shott, Partition; cumulative effects in cascaded/sequential systems; signal-to-noise ratio; noise figure and noise factor; noise temperature

Noise calculations: eg thermal/Johnson noise, signal-to-noise ratio, noise figure, noise factor

Bandwidth and information capacity: Shannon-Hartley theorem eg relationship to the available bandwidth and the signal-to-noise ratio; bandwidth requirements for typical applications (voice, radio and television broadcasting); the implications for both analogue and digital signals

Channel impairments: attenuation and other losses; bandwidth limitation; phase delay; effects on complex signals; inter-symbol interference; bit error rates (typical examples)

3. Understand modulation and multiplexing techniques used for analogue and digital signals

Analogue modulation methods: amplitude/frequency/phase; pulse modulation methods eg pulse amplitude (PAM), pulse position (PPM), pulse duration/width (PDM/PWM)

Modulation methods for digital signals over analogue networks: eg amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), quaternary phase shift keying (QPSK), quaternary amplitude modulation (QAM)

Digital modulation methods: pulse code modulation (PCM); delta modulation; adaptive delta modulation

Multiplexing techniques: space division; frequency division; time division; wavelength division
4 Understand the characteristics of communications traffic

*Telecommunications traffic over circuit switched networks*: call duration; call holding times; call arrival times (coincidence); busy hour; grade of service

*Telecommunications traffic over packet switched networks*: server traffic; network traffic; congestion; congestion control techniques; the effects of delay

*Mathematical formulae*: Erlang B and Erlang C; Little’s theorem and applications to queuing theory
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<tr>
<th><strong>Learning outcomes</strong></th>
<th><strong>Assessment criteria for pass</strong></th>
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<td>On successful completion of this unit a learner will:</td>
<td>The learner can:</td>
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<tr>
<td><strong>LO1</strong> Understand the requirements of communication systems</td>
<td>1.1 describe the elements of communication systems  &lt;br&gt; 1.2 explain the characteristics of electromagnetic waves and their application to communications systems  &lt;br&gt; 1.3 determine the signal spectra for the content of complex waveforms  &lt;br&gt; 1.4 convert from linear to logarithmic relationships (and vice versa) and determine the overall gain/loss of typical communication systems</td>
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<td><strong>LO2</strong> Understand communication channels and their characteristics</td>
<td>2.1 determine the sources and effect of noise found in electronic communication systems, including cumulative factors  &lt;br&gt; 2.2 carry out noise calculations  &lt;br&gt; 2.3 determine the bandwidth and expected information capacity of typical communication systems  &lt;br&gt; 2.4 discuss the various channel impairments and their resultant effect on the maximum system bit rate for digital systems</td>
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<td><strong>LO3</strong> Understand modulation and multiplexing techniques used for analogue and digital signals</td>
<td>3.1 explain the need for modulation and the variety of modulation schemes used for analogue signals  &lt;br&gt; 3.2 discuss the modulation methods used to represent digital data over analogue networks  &lt;br&gt; 3.3 describe the range of digital modulation methods and typical applications  &lt;br&gt; 3.4 explain the reasons for multiplexing signals giving examples of the methods used</td>
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<td><strong>LO4</strong> Understand the characteristics of communications traffic</td>
<td>4.1 evaluate the nature of telecommunications traffic carried over circuit switched networks  &lt;br&gt; 4.2 evaluate the nature of telecommunications traffic carried over packet switched networks  &lt;br&gt; 4.3 apply mathematical formulae to typical examples of telecommunications traffic</td>
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Guidance

Links
This unit can be linked to Unit 1: Analytical Methods for Engineers and Unit 119: Data Communications and Networks.

Essential requirements
There are no essential requirements for this unit.

Employer engagement and vocational contexts
Delivery of this unit will benefit from centres establishing strong links with employers willing to contribute to the delivery of teaching, work-based placements and/or detailed case study materials.