

IMPERIAL COLLEGE LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2003

MSc and EEE PART IV: M.Eng. and ACGI

TRAFFIC THEORY & QUEUEING SYSTEMS

Monday, 19 May 10:00 am

Time allowed: 3:00 hours

There are FIVE questions on this paper.

Answer FOUR questions.

Corrected Copy

Any special instructions for invigilators and information for candidates are on page 1.

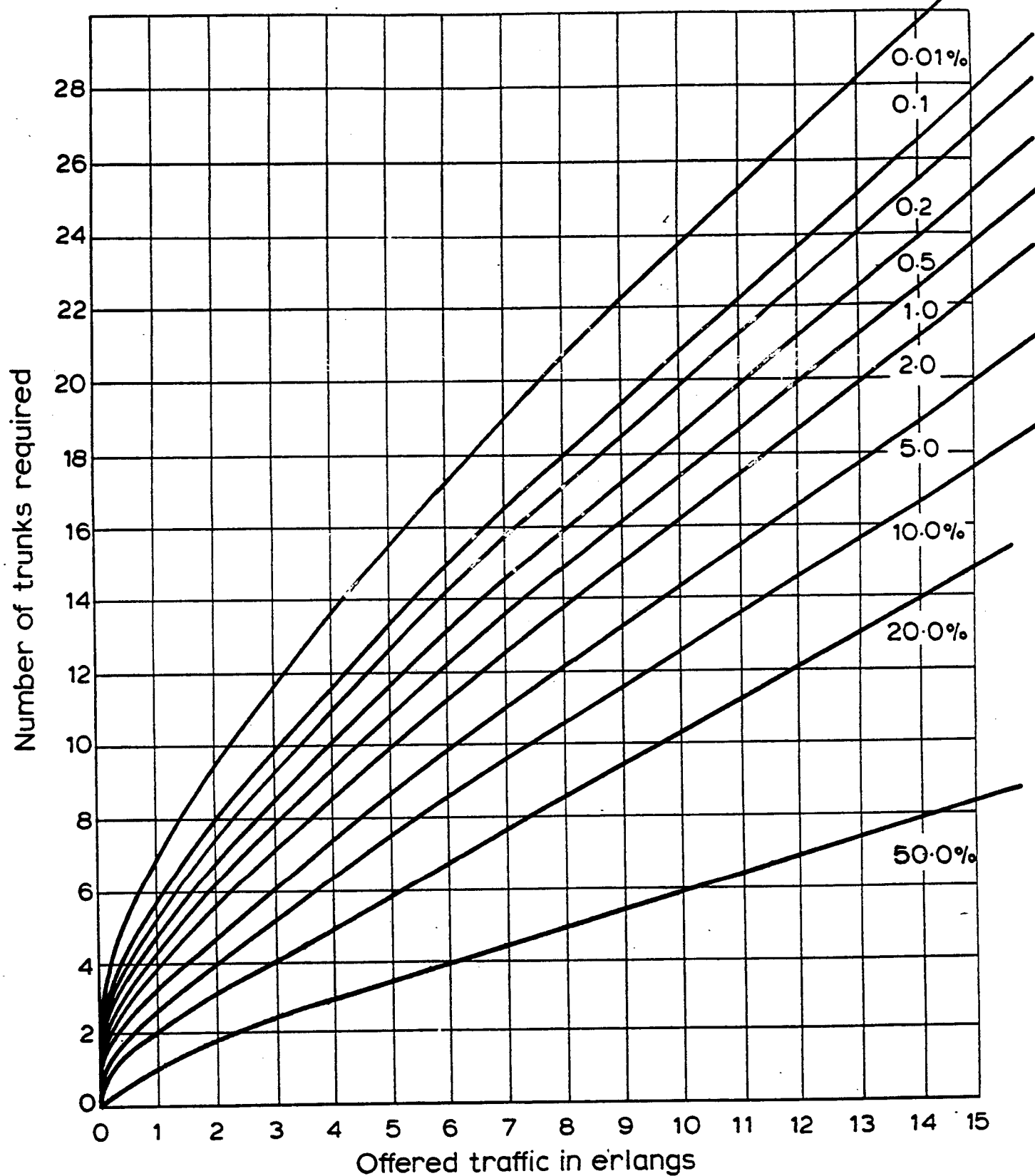
Examiners responsible	First Marker(s) :	J.A. Barria
	Second Marker(s) :	P. De Wilde

Special Information for Invigilators:

NIL

Information for Candidates:

Target grade of service



*Traffic capacity on basis of Erlang B.
formula.*

1. (a) State and discuss the validity of the underlying assumptions of the Erlang model for the traffic carried by an unbuffered multi-channel link. [5]
 - (b) For the Engset model, write down (i) the global balance equations and (ii) the local balance equations and clearly state the corresponding birth/death coefficients. [5]
 - (c) Eight Erlangs of pure chance traffic (Poisson arrival streams and exponential holding times) is offered to a 12-channel communication link. Estimate:
 - (i) The mean of the carried traffic,
 - (ii) The mean channel occupancy, and
 - (iii) The proportion of time for which the link is completely idle (no channel busy). [10]
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2. (a) A communication link consists of a first-choice group of channels of size M which is fed with a Poisson stream of demands with rate λ and a second-choice group of channels of size N . Traffic is only offered to the second-choice group when the first-choice group is saturated. If the channel holding times are exponential with a mean service rate per channel of μ ,
 - (i) Draw the state transition diagram of a Markov model for the traffic pattern on this 2-group link. [3]
 - (ii) Discuss the validity of Local and Global balance equations. [3]
 - (iii) Briefly discuss how you would solve the call blocking probability for the overflow link? [4]
 - (b) In a call centre enquiry system incoming calls are placed in a queue which is served by a FIFO queue discipline by a group of 10 operators. Assuming that the incoming traffic intensity is 8 Erlangs, determine:
 - (i) The probability that an incoming call will be delayed (assume no loss of calls), [5]
 - (ii) The probability that an incoming call will be blocked if the buffer size is five (5) calls only. [5]

3. (a) A buffered system is being offered a pure chance traffic (Poisson arrival stream and exponential service time). The system is composed of K servers and it can be assumed that possesses an infinite buffer size for incoming calls.

If the system is operating with a FIFO queue discipline, what can be said about:

- (i) The waiting-time distribution for arrival that find all K servers busy?
- (ii) The queue-length distribution for delayed arrivals?

[14]

- (b) Mathematically formulate an equivalent representation of the Generic Rate Algorithm (in relation to the UPC (user parameter control) technique proposed by the ATM Forum). Discuss any underlying assumption made.

[6]

4. (a) Discuss the importance of Admission Control in Broadband Networks. Discuss the relevance of the Equivalent capacity functions.

[6]

- (b) A Poisson stream of messages with rate $\lambda = 18000$ messages/minute is fed into a 64 Kbits/seconds single-channel communication link. Assume that no message is lost and if the system is busy the messages can be placed in a buffer.

The message stream consists of a random mixture of 1-packet messages and 2-packet messages. The system gives non-pre-emptive priority to 1-packet messages.

Assuming that each packet is of length $B = 160$ bits and that $\frac{3}{4}$ of the messages are 1-packet messages determine:

- (i) The mean waiting time for 1-packet message,
- (ii) The mean waiting time for 2-packet messages, and
- (iii) The overall mean message waiting time.

[14]

5. (a) Using a two-state voice source model represented in Figure 5.1, derive a composite N-voice traffic source model.

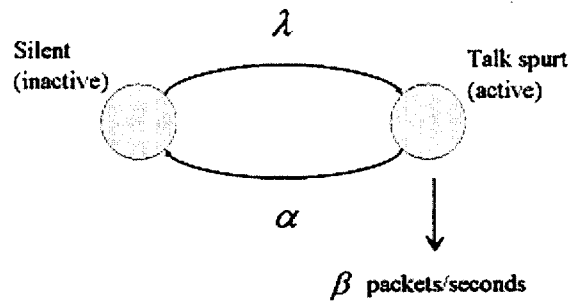


Figure 5.1

- (i) Derive the probability that the N -voice source has i sources active. [2]
 - (ii) Derive the state space representation (or Markov chain) of a voice multiplexer with buffer capacity N . [2]
 - (iii) Assume that the service time distribution of a packet is exponentially distributed with mean $= 1/\nu$ seconds.
 - Obtain the average number of packets entering the system
 - Obtain the system utilisation
- [4]
- (b) Assume the following characteristics of a two-processor degradable system:
- One processor failure rate: $\gamma = 0.2$ [failures/unit_time],
 - One processor repair rate: $\tau = 4.0$ [repairs/unit_time],
 - One processor replacement: $\rho = 8.0$ [replacements/unit_time].

Assume a coverage factor of $c = 0.99$.

Assume also that a job can be divided into parallel subtasks, and that

- The service rate when one processor is operational is $R_I = 1.0$ [service/unit_time],
 - The service rate when two processors are operational is $R_{II} = 1.6$ [service/unit_time].
- (i) Define the state space of the system and its associated Markov chain. [6]
 - (ii) Find the value of $\lim_{t \rightarrow \infty} E[W(t)]$, where $W(t) \equiv Y(t)/t$ and $Y(t)$ is the accumulated reward per unit of time t . [6]