Mark Scheme 2825/05
June 2005

TELECOMMUNICATIONS

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Question 1	Expected Answers			Marks

(a) Typical carrier frequency on MW 300 kHz to 3MHz 1

(b) λ = c / f = 3×10^8 / f

= 1000 m to 100 m (must use their frequency to calculate λ) 1

Dipole length should be λ / 2 which is too long. 1

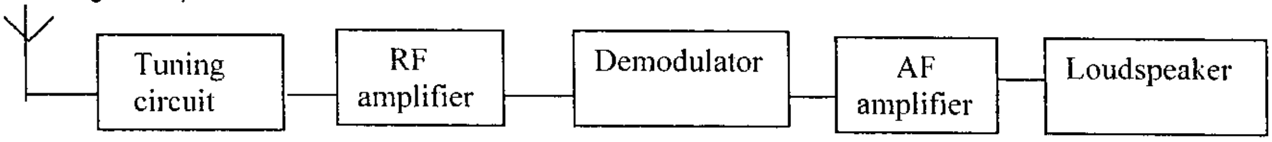
(c) The aerial picks up all three stations so could not discriminate

The aerial signal will be too weak to drive a moving coil loudspeaker

The average value of the AM aerial signal is zero anyway (any two sensible points) 1 1

(d)

1 1 1 1 (deduct 1 mark for each wrong order)



Aerial	Converts e.m. waves into tiny ac currents	
Loudspeaker	Converts electrical signal into sound (any sensible comment on either)	1
Tuning circuit	Selects one carrier frequency and rejects others	1
<u>RF</u> amplifier	Amplifies carrier frequency so the demodulator can work	1
Demodulator	Extracts audio signal from carrier and rejects carrier	1
<u>AF</u> amplifier	Amplifies audio signal to be able to drive loudspeaker	1

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Question 2	Expected Answers			Marks

(a) If the voltage A is greater than B the op-amp output will saturate + vely
If the voltage A is less than B the op-amp output will saturate - vely 1

If the voltage at A is equal to B the op-amp output will be zero 1

(b) LDR symbol ringed 1

(c) Voltage at B = (27 / 27 + 48) x 15 1

= 5.4 V 1 (for an answer of 9.6V allow 1 mark)

(d) Voltage at A = (3.3 / 3.3 + 6.2) x 15

1 = 5.2V 1

So the op-amp output will be <u>- ve</u> 14 V 1 (allow saturation -13V to -15V)

And the LED will be ON 1 (watch out for e.c.f.)

(e) In darkness the voltage at A < B so the LED is ON 1

It will stay ON <u>without a change in brightness</u> 1

Then it will go out and stay out as the conditions darken 1
(LDR resistance at switch point is 5.87 kΩ)

(f) R = pd / current (must have 30V or 29V or 28V across system)

= (15 - 2 - - 14) / 5 mA 1 (must consider any LED turn on, even 0.7V, or make a sensible comment on need for a value lower than 6 kΩ)

= 27 / 5 mA 1

= 5400 Ω 1

(allow 1 mark for any sensible comment on switch on voltage of LED)
(for 30V / 5ma = 6 kΩ allow 2 marks for 15V / 5ma = 3 kΩ allow 1 mark)

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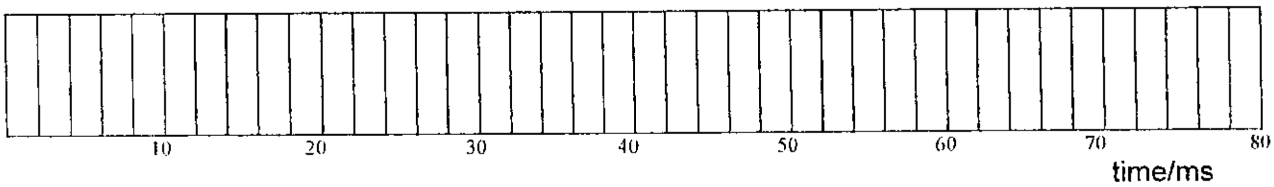
Question 3	Expected Answers			Marks

(a) Separation of successive samples are 1/25 = 40 ms 1

(b)



Correct binary equivalents 111 (all five signals in binary order 3 marks, deduct 1 mark per error)
Correct position in time of digital signals 1
(If not in TDM order then mark up to max of 2 / 4)

Most significant bit marked 1

(c) Each sample lasts for 4 x 2 ms = 8 ms 1

Time between samples = 1 / 25 = 40 ms

Maximum number = 40 / 8 = 5 1 (allow 1 mark for 40 / 10 = 4)

(d) Maximum signal frequency must be less than 2 x sampling frequency 1

Hence less than 12.5 Hz (but allow 12.5 Hz) 1

(e) To increase the number of TDM signals

1. Reduce the 2ms bit duration 1

2. Reduce the number 4 of bits per sample 1

3. Reduce the 25 Hz sampling frequency 1

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Question 4	Expected Answers			Marks

(a) The extreme purity means very low power loss / low attenuation 1
This allows the signal to be amplified / regenerated much less frequently 1
The different refractive indices means the core can be a higher n than the cladding 1
This allows protection of core but still allowing total internal reflection to occur 1

eg

Optic fibre has higher bandwidth	so greater multiplexing / information capacity
Optic fibres do not radiate energy	so there is no cross-talk between fibres
Optic fibre is immune to em waves	so can be used in noisy environments
Optic fibre cannot be tapped	so is much more secure
Optic fibre is thinner and lighter	so is easier for technicians to handle
Optic fibre glass is common substance	so is cheaper than copper

(allow any 3 sensible state & explains x 2 marks each)

(b) (i) Signal-to-noise 25 $= 10 \log P_{sig} / 6.3 \times 10^{-6}$ 1

lowest signal power P_{sig} $= 6.3 \times 10^{-6} \times 10^{2.5}$

$= 2.0 \times 10^{-3}$ W 1

(ii) Total attenuation in fibre $= 10 \log 38 \times 10^{-3} / 2.0 \times 10^{-3}$

$= 12.79$ dB 1

Attenuation per unit length $= 12.79 / 80$

$= 0.16$ 1 dB km^{-1} 1 (for unit)

(iii) Speed of light in fibre $= 3.0 \times 10^{8} / 1.5$

$= 2.0 \times 10^{8}$ 1

minimum time $= 80 \times 10^{3} / 2.0 \times 10^{8}$

$= 400$ μs 1 (allow 1 mark for 267μs)

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Question 5	Expected Answers			Marks

(a) *Audio* refers to frequencies between 20 Hz and 20 kHz or
refers to sound waves that can be heard by human ear 1

Analogue refers to a signal which is analogous to the quantity which generated it
It varies continuously in time
And can have any value between two limits 1 (any point)

Digital This is a coded representation of information
Can only have one of two values 1 (either point)

(b)
(i) Total number of bits stored $= 2 \times 16 \times 44100 \times 3600$ 1
$= 5.08 \times 10^9$ 1

(ii) Received bit rate $= 5.08 \times 10^9 \ / \ 3600$
$= 1.4 \times 10^6 \ s^{-1}$ 1

(c) Advantages of digital
Digital signals can be perfectly regenerated
Digital signals can be easily stored in memories
Digital signals can be easily controlled by computers
Digital signals can be companded
Digital signals can be encrypted
Digital signals can have error correction
Digital allows store of greater volume of information
(any two sensible points) 1 1

(d)
(i) Total number of combinations $= 2^{\text{number of bits}}$

$2^7 = 128$ so 7 bits required 1

(ii) Typical page of text ≈ 40 lines / page x 60 characters / line x 7 bits per character

≈ 16800 1 1 (accept any reasonable and explained answer)

(iii) Total number of pages ≈ $5.08 \times 10^9 \ / \ 16800$

≈ 3×10^5 pages (must be (b)(i) / (d) (ii)) 1

Mark Scheme: 2825 Synoptic Common question

(a)(i) speed $v = 2\pi r / t$
$v = 2 \times \pi \times 122/2 /(30 \times 60)$ (1)
$v = 0.21$ m s^{-1} (1) allow 0.2 m s^{-1}

(ii) F = 12.5 kN x 16 = 200 kN (1)

(iii) W = F x s or
= 200 k x 2 x π x 122 / 2 (1) ecf (ii) allow ecf for distance from (i)
= 7.7×10^7 J (1) allow 8×10^7

(iv) P = W / t energy / time or F x v or
= $7.67 \times 10^7 / (30 \times 60)$ (1) or ecf (iii) / (30 x 60)
= 42.6 kW (1) allow 43 kW only allow 40 kW if working shown

(v)
- Friction force at bearing opposes motion so not useful (1)
- Friction force of tyres on rim drives wheel, so is useful (1)
- Electrical energy supplies power to drive wheels / useful implied (1)
- Input energy (electrical or energy supplied to motor) is converted into heat (1)

Last point to do with the idea that once moving with constant speed e.g.
- All work is done against friction
- No input energy is converted into E_k
- All input energy ends up as heat
- Any other relevant point relating to energy (1)

(b)(i) X is bigger than Y (as X is under greater tension due to the weight of the bike) (1)

(iii) Q is bigger than P (due to the weight of the wheel causing compression in P) (1)

(c)(i) k = F / x
= $1.8 \times 10^6 / 0.90$ (1)
= 2.0×10^6 Nm^{-1} (1)

(ii) $f = (1/2\pi\ (k/m)^{0.5}$ (0)
= $(1/2\pi\ (2.0 \times 10^6 / 9.5 \times 10^5)^{0.5}$ (1)
= 0.23 Hz (1)

(iii) If wind energy causes this frequency in the structure, the amplitude increases / resonance occurs / or explanation of resonance / ref. to natural frequency (1)
e.g. damping is necessary / mass change to shift resonant frequency / change spring constant (1)