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RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **2825/05**

Telecommunications

Mark Scheme for June 2010

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Mark Scheme Page 1 of 5	Unit Code 2825	Session June	Year 2010	Version
Question 1	Expected Answers			Marks

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

(b) $\lambda = c / f = 3 \times 10^8 / f$

$= 1000$ m to 100 m 1

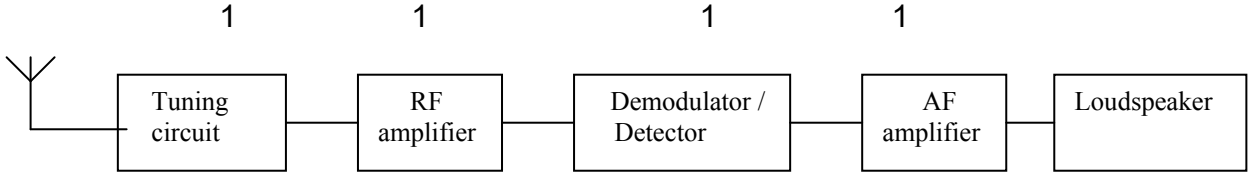
Even with a dipole length of $\lambda / 2$ this is too long. 1

(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) 2

(d)



Aerial	Converts e.m. waves into tiny ac currents	1
Tuning circuit	Selects one carrier frequency and rejects others	1
RF amplifier	Amplifies carrier frequency So the demodulator can work	1
Demodulator (or detector)	Extracts audio signal from carrier and rejects carrier	1
AF amplifier	Amplifies audio signal to be able to drive loudspeaker	1
Loudspeaker	Converts electrical signal into sound	1

Mark Scheme Page 2 of 5	Unit Code 2825	Session June	Year 2010	Version
Question 2	Expected Answers			Marks

(a) Attenuation The gradual loss in Power (or Energy) of signal in transmission 1

(b) (i) The cable will attenuate higher frequencies more than lower ones 1

(4km of 10dBkm^{-1} means a 40dB loss which means a 10^4 fold power loss)

the music will lose its treble and sound bassy 1

(ii) The attenuation below 3kHz is more or less constant

So all frequencies in range will be equally attenuated 1

And speech will sound the same as that transmitted (although quieter) 1

(c) (i) Signal-to-noise ratio 25 = 10 log P_{min} / 8.6 x 10^{-6} 1

Thus P_{min} = $10^{2.5}$ x 8.6 x 10^{-6} 1

= 2.72 x 10^{-3} W 1

(ii) Total attenuation = 10 log 2.72 x 10^{-3} / 2.7 1

= - 30 dB 1

(iii) Max uninterrupted length = 30 / 4.0

= 7.5 km 1

(iv) The signal must be amplified 1

Each amplifier must have a gain of (10 log 2.7 / 2.72 mW) = 30 dB 1

There must be amplifiers placed every 7.5 km thus 30 / 7.5 = 4 are needed 1

Mark Scheme Page 3 of 5	Unit Code 2825	Session June	Year 2010	Version
Question 3	Expected Answers			Marks

(a) LDR symbol labelled
LED symbol labelled 1

(b) If the voltage X is greater than Y the op-amp output will saturate + vely
If the voltage at X is equal to Y the op-amp output will be zero
If the voltage X is less than Y the op-amp output will saturate – vely
Any sensible comment on transition from –ve to +ve saturation
(3 marks for three points) 3

(c) Voltage at Y = (39 / 39 + 51) x 15 1
= 6.50 V 1

(d) Voltage at X = (2.2 / 2.2 + 2.9) x 15
= 6.47 V 1

So the op-amp output will be - 14 V (allow any -ve saturation -13V to -15V) 1

And the LED will be ON 1

(e) In darkness the voltage at X < Y so the LED is ON
It will stay ON <u>without a change in brightness</u> 1
Until daylight when LDR resistance becomes less than about 3 kΩ 1
Then it will go out and stay out as the conditions lighten 1

(f) R = pd / current (must have 30V or 29V or 28V across system)
= (15 - 2 - - 14) / 5 mA (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
= 5400 Ω 3

(allow only 2 marks for 30V / 5ma = 6 kΩ)

(allow only 1 mark for 15V / 5ma = 3 kΩ)

Mark Scheme	Unit Code	Session	Year	Version
Page 4 of 5	2825	June	2010	
Question 4	Expected Answers			Marks

(a) Satellite must have an orbital period of 24 hours 1

Satellite must orbit directly above equator 1

Satellite must orbit in same sense as Earth spins 1

(b) Satellite requires power from somewhere and (if no RTG used) then sun is only source
Solar panels are not always in direct sunlight (sometimes in Earth's shadow)
Batteries are required to maintain steady power consumption

(any two) 2

(c) Input power to solar panel = $1.6 \times 10^3 \times 3.5$ 1

= 5600 W 1

Efficiency = 1120 / 5600

= 20 % 1

(d) Power transmitted into footprint = 0.90 x 650 = 585 W 1

Power received by dish = $\{ \pi (0.85 \div 2)^2 / \pi (1200 \times 10^3 \div 2)^2 \} \times 585$ 1

= $\{ 0.85^2 / 1200000^2 \} \times 585$ 1

= 2.94×10^{-10} W 1

(e) The TV station transmits from (a parabolic dish) Earth directly to satellite
On a carrier frequency in the order of GHz.
The satellite picks up this signal and amplifies it
The satellite changes the carrier frequency of this signal (eg from 14 GHz to 11 GHz)
In order to avoid feedback / interference / swamping incoming signal with outgoing

(any three) 3

(f) Satellite system covers huge area with one single transmitter on one carrier frequency
Terrestrial system would require very large number of transmitters
Each operating on slightly different frequencies
So uses bandwidth much more efficiently

(any two) 2

Mark Scheme Page 5 of 5	Unit Code 2825 / 05	Session June	Year 2010	Version
Question 5	Expected Answers			Marks

System uses carrier frequencies in the UHF region / GHz region

This means wavelengths being used are in the order of centimetres

The size of a receiving dipole aerial is in the order of a centimetre

This means small and inconspicuous aerials can be used to transmit and receive

[2]

Low power transmitted from handset means minimum radiation risk to user

Waves in the UHF region travel by line-of-sight so have limited terrestrial range

Low power transmitters mean the same frequencies can be used as carriers over and over again

[2]

Country is divided into cells

Each cell is normally in the order of a few km radius (but can be few hundred metres in cities)

At the centre of each cell is a base station

Several base stations from a cluster of cells are connected to a cellular exchange

The cellular exchange is connected to the Public Switched Telephone Network (PSTN)

[3]

When mobile phone is activated it transmits an identifying digital signal

This signal is picked up by a number of base stations under the control of cellular exchange

Cellular exchange selects appropriate base station through which to link mobile to PSTN

So that user can be connected to home

or any further relevant point

[2]

6

(a) mg Δh / gravitational potential energy / of upper carriage decreases /is converted into.....B1
gravitational energy of lower carriage.....B1
and E_k of carriage(s).....B1
allow for the third mark ref. to heat in brakes / work done against friction

(b) $T_1 = mg \sin\theta$
$T_1 = 10000 \times 9.81 \times 150 / 260$ or $10000 \times 9.81 \times \sin 35$.....B1
$T_1 = 5.7 \times 10^4$ N or 5.66, 5.63, 5.62 x 10^4 N B1

(c)(i) $m=F/a$, $8.7 \times 10^3 / 1.5$ C1
$= 5.8 \times 10^3$ kg.....C1
$m = 10000 – 5800 = 4200$ kg C1
$V = m / \rho$
$V = 4.2 \times 10^3 / 1000 = 4.2\ m^3$ A1

(ii) $t = (v-u) / a$
$t = 6.6 / 1.5$ C1
$t = 4.4$ s A1

(iii) $s = ut + 0.5 \times a \times t^2$
$= 0 + 0.5 \times 1.5 \times 4.4^2$ C1
= 14.5 m or 15 m.....A1

(d) (i) 3800 x 9.81 x 150 = change in gpe.....B1
= 5.6 or 5.59 MJ B1

(ii) $E = m c \Delta T$.....C1

$5.5 \times 10^6 = 6 \times 25 \times 470 \times \Delta T$ C1
ΔT = 78 K allow 79 K if 5.6 MJ used A1

(iii) some thermal energy is lost to the surroundings / brakes lose heat.....B1
sensible explanation, ...B1
e.g. mechanism e.g. radiation, by which energy is transferred or
to where the thermal energy might also be transferred e.g. cable or pulley

Total 20

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