Digital technology review answers

Analogue and digital signals

1) (a) Binary 10111 **= 16+4+2+1=23** decimal (b) Write 200 as a binary number: **11001000**

2) Compare one digital **(DVD)** and one analogue **(Video tape)** storage method for video in terms of:

(a) The medium and method used to store the data **DVD – optical (pits on a track)** Tape – **magnetic (alignment of magnetic domains)**

(b) The method of data retrieval **DVD – laser light (interference/no interference), coil of wire (induction from moving tape)**

(c) The accuracy of the data storage and retrieval. **DVD – accurate but digitized unless scratched, tape – never 100% accurate and reduced accuracy over time.**

3) A standard CD can store 700 MB (700×2^{20} bytes) of data [http://en.wikipedia.org/wiki/Compact_Disc]. The distance between the tracks, the pitch, is 1.6 µm. The storage area occupies a radius from 25 to 58 mm. Scanning velocity is approximately 1.3 ms^{-1}. Approximate:

(a) The number of tracks that would fit into the storage area of the disc?

$(0.058-0.025)/1.6\times10^{-6}$ = 20625 tracks

(b) The average circumference of a track?

Average radius =(58+25)/21 mm, circumference = $2\pi r$ = 260mm

(c) The total track distance and the distance along the track that one bit of data occupies

Track distance = 20625x0.26m=5378m, Number of bits = 700 x 2^{20} x 8 = 5.87×10^{9}.

one bit occupies 5378m/5.87×10^{9} =0.9 µm

(d) The time taken to play a full CD and the bit rate of data retrieval.

Time taken to play a CD is about 70 minutes so bit rate is **700 x 2^{20} x 8 / (70x60) = 1.4×10^{6} bits/sec.**

which mean 1.4×10^{6}x0.9 µm = 1.3ms^{-1}

4) Outline the advantages of storing data in a digital format compared to an analogue format.

Accurate retrieval, easily transferred between devices, high density of data storage.

5) "The global information and communications technology (ICT) industry generates as much CO_2 as aviation" [http://www.pcpro.co.uk/news/111643/computing-rivals-aviation-for-co2-emissions-gartner]

(a) "Computers use electricity not fuel." Explain what is meant by this statement.

It is possible for the ICT industry to run off renewable energy but not the aviation industry.

(b) What else, apart from running computers cause the ICT industry to generate CO_2?

Manufacture of digital devices.

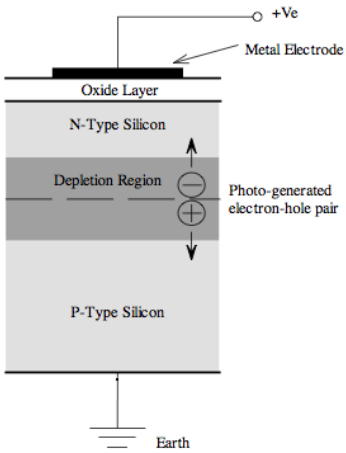
(c) Discuss one ethical consideration of storing vast amounts of data digitally.

Data could be stolen and misused.

CCD's [http://www.vikdhillon.staff.shef.ac.uk/teaching/phy217/detectors/phy217_det_structure.html]

6) Define capacitance.

The ratio of charge stored to potential difference across a device.



7) By referring to the diagram on the right explain how a CCD device is similar to an array of capacitors that are charged up by light.

The photo generated electron is attracted to the metal electrode so becomes stored under the oxide layer.

8) What is measured and converted to a light level for each pixel?

(a) Current **(b) Potential Difference** (c) Charge (d) Capacitance

9) Use the formula Q = VC to explain how the number of photons effects the measurement made from each pixel. **The more charge (Q) trapped in the capacitor the greater the potential difference.**

10) Define quantum efficiency of a pixel

Number of photoelectrons stored / Number of photons of appropriate frequency received.

11) Define magnification and explain why a magnification of 1/10 results in an image being 1/100 the size of the object.

Magnification is ratio of object length to image length so area changes are the square of magnification.

12) How much gap must their be (in pixels) between two parts of an image for the two parts to be resolved on an image? **At least two pixel widths.**

13) The Hubble Space telescope has a CCD array that is sensitive to radiation from ultraviolet to near infra-red. What range of wavelengths is this:

(a) 20- 1000 fm (b) 20 – 1000pm **(c) 20- 1000 nm** (d) 20- 1000 µm

14) Outline some uses of CCD devices in systems that detect parts of the electro-magnetic spectrum not visible to the eye.

Radio telescopes, X-ray cameras for space…