Clifton College

Physics Department

Advancing Physics AS

Chapter Test 1

Name:

Set:

1. An ultrasound emitter produces ultrasound at a *frequency of 1MHz*.
The speed of sound in air can be taken to be 340 ms^{-1}

(a) Explain what is meant by the phrase in italics in the first sentence.

The ultrasound causes 1 million oscillations per second

[1]

(b) Calculate the time period of the ultrasound.

$T = 1 / f = 1 / 1 \times 10^{6} = 1 \times 10^{-6}$ s = 1 μ s

[2]

(c) Calculate the wavelength of the ultrasound.

$\lambda = v / f = 340 / 1 \times 10^{6} = 3.4 \times 10^{-4}$ m

[2]

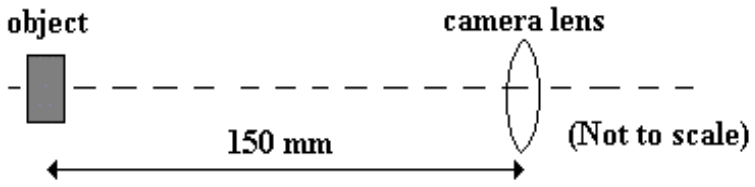
2. A camera lens is marked with having a focal length of 20.0 mm.

(a) Calculate the power of the lens.

$P = 1 / f = 1 / 0.02 = 50$ D

[2]

(b) A girl wishes to take a photograph of an object 150 mm away.



Calculate how far she should adjust the camera lens from the film, in order for the object to be in focus on the film.

$1 / v = 1 / u + 1 / f$
$1 / v = (1 / - 0.15) + 50 = 43.3333$
$v = 0.023$ m = 23 mm

[3]

(c) Calculate the linear magnification of the lens using your answer to part (b)

$m = v / u = 23 / (-150) = - 1.5 \times 10^{-4}$

[3]

2. This question is about an image taken by a digital infrared camera.
The speed of light in air can be taken as 3.00×10^{8} ms^{-1}.

(a) The typical wavelength of infrared light is 10 μm.
Calculate the typical frequency of infrared light.

$f = v / \lambda = 3 \times 10^{8} / 10 \times 10^{-6} = 3 \times 10^{13}$ Hz

[3]

The digital camera records the image onto a 1000 x 1000 array of detectors which act as pixels. Each detector records the strength of the incident infrared on a scale from 0 to 15.

(b) How many bits of information does each pixel need in order to do this?

4 bits needed $(2^4 = 16)$

[1]

(c) How much information does a complete image hold?

$4 \times 1000 \times 1000 = 4 \times 10^{6}$ bits

[2]

(d) How many bytes of information are in one complete image?

$4 \times 10^{6} / 8 = 500{,}000$ bytes

[1]

(e) A floppy disc can store 1.44 MB of information.
How many *complete* images could a floppy disc store?

$1.44 \times 10^{6} / 5 \times 10^{5} = 2.88$ hence 2 full images

[1]

The camera is used to record an overhead image of a town during the night.
The width of the image recorded represents 5km of the town.

(f) Calculate the resolution of the image.

5000 / 1000 = 5 m

[2]

2. This question is about image processing

(a) What is meant by *noise* in an image?

Anomalous data / random fluctuations in signal

[1]

(b) Explain one method of *smoothing* an image.

METHOD A
Replacing a pixel by the **mean** of itself and its neighbours

METHOD B
Replacing a pixel by the **median** of itself and its neighbours

(I gave 1 or 2 marks depending upon quality of explanation)

[2]

Below is an array of numbers, each one representing a pixel.

20	20	30	20	20
20	30	40	30	20
20	20	30	20	20

(a) Use the smoothing method that you explained in (b) on the three central pixel in the array (the shaded ones). Complete the grid below to give your answers.

(remember that the value can only be a whole number)

20	20	30	20	20
20				20
20	20	30	20	20

26, 27, 26 OR 20, 30, 20 [3]

(a) State a disadvantage of repetitively smoothing an image.

Loss of detail

[1]