**M1.** (a) any **two** from:

- travel (at same speed) through a vacuum / space
  *do **not** accept air for vacuum*
- transverse
- transfer energy
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- travel in straight lines

**2**

(b) can pass through the ionosphere
*accept atmosphere for ionosphere*
*do **not** accept air for ionosphere*
*accept travel in straight lines*
*accept not refracted / reflected / absorbed by the ionosphere*

**1**

(c) $v = f \lambda$

$1.2 \times 10^6$ / 1200 000
*allow **1** mark for correct substitution*
*ie $3.0 \times 10^8 = f \times 2.5 \times 10^2$*

**2**

hertz / Hz
*do **not** accept hz **or** HZ*
*accept kHz **or** MHz*
*answers 1.2 MHz **or** 1200 kHz gain all **3** marks*
*for full credit the unit and numerical value must be consistent*

**1**

**[6]**

**M2.** (a) (i) gamma

*accept correct symbol*

**1**

(ii) any **one** from:

- (ultraviolet has a) higher frequency

  *ultraviolet cannot be seen is insufficient*
- (ultraviolet has a) greater energy
- (ultraviolet has a) shorter wavelength

  *ignore ultraviolet causes cancer etc*

**1**

(b) $1.2 \times 10^7$ / 12 000 000

*allow **1** mark for correct substitution, ie $3 \times 10^8 = f \times 25$*

**2**

hertz / Hz / kHz / MHz

*do **not** accept hz **or** HZ*

*answers 12 000 kHz **or** 12 MHz gain **3** marks*

*for full credit the numerical answer and unit must be consistent*

**1**

(c) (i) away (from each other)

*accept away (from the Earth)*
*accept receding*

**1**

(ii) distance (from the Earth)

*accept how far away (it is)*

**1**

speed galaxy is moving **1**

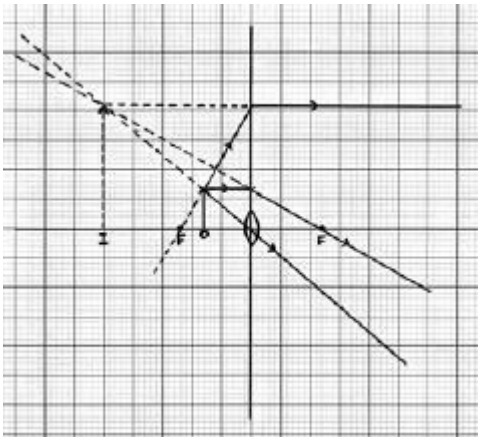
(iii) (Universe is) expanding **1**

**[9]**

**M3.** (a) (i) **two** correct rays drawn

***1*** *mark for each correct ray*

- ray parallel to axis from top of object **and** refracted through focus **and** traced back beyond object
- ray through centre of lens **and** traced back beyond object
- ray joining top of object to focus on left of lens taken to the lens refracted parallel to axis **and** traced back parallel to axis beyond object



**2**

an arrow showing the position **and** correct orientation of the image for their rays

*to gain this mark, the arrow must go from the intersection of the traced-back rays to the axis **and** the image must be on the same side of the lens as the object and above the axis*

**1**

(ii) (x) 3.0

*accept 3.0 to 3.5 inclusive*

**or**

$$\frac{\text{their image height}}{\text{object height}}$$

correctly calculated

*allow **1** mark for correct substitution into equation using their figures*

*ignore any units*

**2**

(b) any **two** from:

in a camera the image is:

- real not virtual
- inverted and not upright

  *accept upside down for inverted*
- diminished and not magnified

  *accept smaller and bigger*
  *accept converse answers but it must be clear the direction of the comparison*

  *both parts of each marking point are required*

**2**

**[7]**

**M4.** (a) (i) to check rise in temperature (of other thermometers) was due to the (different wavelengths of) light

*accept as a control / comparison*

*to measure room temperature is insufficient*

**1**

(ii) any **two** from three:

- different colours produce different heating effects / (rises in) temperatures
- red light produces the greatest heating effect / (rise in) temperature

**or**

- violet produces the least heating effect / (rise in) temperature
- all colours produce a greater heating effect than outside the spectrum

*an answer*

*the longer the wavelength the greater the (rise in) temperature*

***or***

*the lower the frequency the greater the (rise in) temperature*

*gains both marks*

**2**

(b) move a thermometer into the infrared region / just beyond the red light

*allow use an infrared camera / infrared sensor*

**1**

the temperature increases beyond 24(°C)

*accept temperature higher than for the red light*

**1**

(c) $v = f \times \lambda$

$9.4 \times 10^{-6}$

*accept $9.375 \times 10^{-6}$ or $9.38 \times 10^{-6}$*

**or**

0.0000094

*accept 0.000009375*
***or** 0.00000938*
*allow **1** mark for correct substitution*
*ie* $3 \times 10^{8} = 3.2 \times 10^{13} \times \lambda$

**2**

(d) at night the surroundings are cooler
*accept at night the air is colder*
*there is no heat from the Sun is insufficient*

**or**

at night there is a greater temperature difference between people and surroundings

**1**

(so surroundings) emit less infrared (than in daytime)
*accept camera detects a greater contrast*

**or**

gives larger difference in infrared emitted (between people and surroundings)

**1**

**[9]**

**M5.**(a) (i) frequency

**1**

wavelength

**1**

(ii) $10^{-15}$ to $10^{4}$

**1**

(b) $2.0 \times 10^{5}$

*correct substitution of*
*$3.0 \times 10^{8}$ / 1500 gains **1** mark*

**2**

Hz

**1**

(c) (i) (skin) burns

**1**

(ii) skin cancer / blindness

**1**

(d) (i) any **one** from:

- (detecting) bone fractures
- (detecting) dental problems
- treating cancer

**1**

(ii) any **one** from:

- affect photographic film
- absorbed by bone
- transmitted by soft tissue

- kill (cancer) cells

  *answer must link to answer given in **(d)(i)***

**1**

(iii) 9 / 36 = 0.25
0.5 / 2 = 0.25
4 / 16 = 0.25

*accept:*

*36 / 9 = 4*

*2 / 0.5 = 4*

*16 / 4 = 4*

**2**

conclusion based on calculation

*two calculations correct with a valid conclusion scores **2** marks*

*one correct calculation of k scores **1** mark*

**1**

**[13]**

**M6.** (a) C or 0.18 mm

**1**

(b) 0.6 (m)

*allow **1** mark for correct substitution and/or transformation **or** **1** mark for changing frequency to Hz*
*answer 600 gains **1** mark*

**2**

(c) creates an alternating current

*accept 'ac' for alternating currentaccept alternating voltage*

**1**

with the same frequency as the radio wave

*accept signal for radio wave*

*accept it gets hotter for **1** mark provided no other marks scored*

**1**

(d) X-rays cannot penetrate the atmosphere

*accept atmosphere stops X-rays*

*do **not** accept atmosphere in the way*

**or**

X-rays are absorbed (by the atmosphere) before reaching Earth

*ignore explanations*

**1**

**[6]**

**M7.** (for both fibres) increasing the wavelength of light decreases and then increases the percentage / amount of light transmitted

*accept for **1** mark:*
*(for both fibres) increasing the wavelength (of light) to 5 (x $10^{-7}$ metres), decreases the (percentage) transmission*

**1**

(for both fibres) the minimum transmission happens at 5 (x $10^{-7}$ metres)
**or**
maximum transmission occurs at 6.5 (x $10^{-7}$ metres)

*accept for a further **1** mark:*

*(for both fibres) increasing the wavelength of the light from 5 (x $10^{-7}$ metres) increases the amount of light transmitted*

*increasing wavelength (of light), decreases the percentage transmitted is insufficient on its own*

**1**

the shorter fibre transmits a greater percentage of light (at the same wavelength)

*accept for **1** mark:*
*Any statement that correctly processes data to compare the fibres*

**1**

**[3]**

**M8.** (a) $10^{-15}$ metres to $10^{4}$ metres

**1**

(b) (i) any **one** from:

- (TV / video / DVD) remote controls
  *mobile phones is insufficient*
- (short range) data transmission
  *accept specific example, eg linking computer peripherals*
- optical fibre (signals)
  *do **not** accept Bluetooth*

**1**

(ii) 0.17

*an answer 17 cm gains **3** marks*

*an answer given to more than 2 significant figures that rounds to*

*0.17 gains **2** marks*

*allow **1** mark for correct substitution, ie* $3 \times 10^{8} = 1.8 \times 10^{9} \times \lambda$

**3**

(c) (maybe) other factors involved

*accept a named 'sensible' factor, eg higher stress / sedentary lifestyle / overweight / smoking more / diet / hot office / age*

*not testing enough people is insufficient*

*unreliable data is insufficient*

**1**

**[6]**