Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$F = 19{\cdot}5\sin 14{\cdot}0$ **(1)** $F_R = (2 \times 19{\cdot}5\sin 14{\cdot}0)$ = 9·43 N **(1)** **OR** $F_R = 2 \times 19{\cdot}5\sin 14{\cdot}0$ **(1)** F_R = 9·43 N **(1)**	**2**	Accept: 9·4, 9·435, 9·4350 Or by scale diagram: 1 for suitable scale diagram 1 for correct answer
		(ii)	No resultant force in this direction/ the sideways direction **OR** Unbalanced force in this direction/ the sideways direction is 0 N **OR** The components of the force at 90° to the direction of the movement are equal and opposite/balanced. **(1)**	**1**	Accept reference to horizontal forces/left and right direction, since the diagram orientation makes it clear which forces are being referred to. Do not accept: 'the forces are balanced' alone
	(b)	(i)	$I = \frac{P}{A}$ **(1)** $11800 = \frac{P}{1{\cdot}24 \times 10^{-5}}$ **(1)** $P = \frac{E}{t}$ **(1)** $\left(11800 \times 1{\cdot}24 \times 10^{-5}\right) = \frac{2{\cdot}10}{t}$ **(1)** $t = 14{\cdot}4$ s **(1)**	**5**	Accept: 14, 14·35, 14·352 $I = \frac{P}{A}$ anywhere, 1 mark $P = \frac{E}{t}$ anywhere, 1 mark
		(ii)	$6{\cdot}3 \times 0{\cdot}30^2 = 0{\cdot}57$ $3{\cdot}5 \times 0{\cdot}40^2 = 0{\cdot}56$ $2{\cdot}3 \times 0{\cdot}50^2 = 0{\cdot}58$ $1{\cdot}6 \times 0{\cdot}60^2 = 0{\cdot}58$ **(2)** Statement of $I \times d^2$ = constant, so LED is a point source **(1)**	**3**	All four calculations correct (2) Three calculations correct (1) <Three calculations correct (0) This conclusion mark is only available if consistent with the calculations shown. Graphical method: Graph drawn correctly (1) Best fit line through origin (1) Statement of $I \propto \frac{1}{d^2}$, so LED is a point source (1)
		(iii) (A)	A semiconductor that has (specific) impurities added	**1**	

Question			Expected response	Max mark	Additional guidance
		(B)		**3**	Any answer using recombination of holes and electrons **on its own**, with no reference to band theory, is worth 0 marks Any wrong physics eg holes move up (from valence band to conduction band)- 0 marks
			(Voltage applied causes) electrons to move from the conduction band of the n-type (semiconductor) towards the conduction band of the p-type (semiconductor). **(1)**		To access this mark, the direction the electrons move must be clear.
			Electrons 'fall' from the conduction band into the valence band (on either side of the junction) **(1)**		To access this mark, valence and conduction bands must be included in the answer. Do not accept: 'valency' as a name for the valence band or 'conductive' as a name for the conduction band.
			Photons are emitted. **(1)**		This mark is dependent upon having at least one of the first two statements.

Q9(a)(i) Maximum mark: 2

Response A **Marks**

$F = 19.5 \times \sin 14°$

$= 4.72$

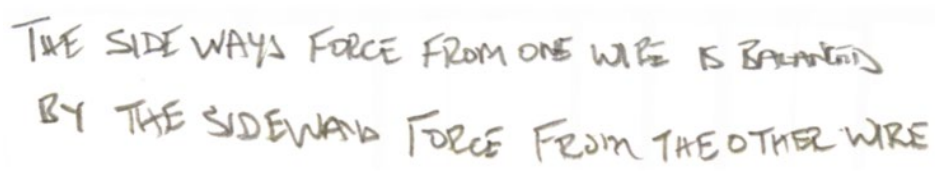
$F_{RES} = 2 \times 4.72 = 9.44\ N$

Response B

$F_T = 2 \times 19.5 \sin 14 = 9\ N$

Q9(a)(ii) Maximum mark: 1

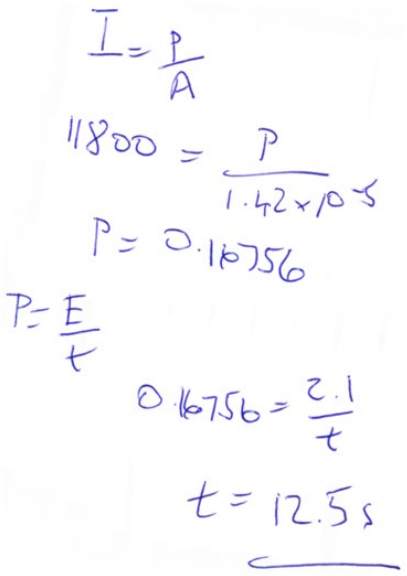
Response A **Marks**



Q9(b)(i) Maximum mark: 5

Response A

Marks



Q9(b)(ii) Maximum mark: 3

Response A

Marks

$6.3 \times 0.3^2 = 0.567$

$3.5 \times 0.4^2 = 0.56$

$2.3 \times 0.5^2 = 0.575$

$1.6 \times 0.6^2 = 0.576$

As the results are all similar the LED acts as a point source.

Response B

d	I	Id^2
0.30	6.3	0.567
0.40	3.5	0.56
0.50	2.3	0.575
0.60	1.6	0.576

$4 \overline{)2.278}$

0.5695

$Id^2 = 0.5695$

so LED is a point source

Q9(b)(iii)A **Maximum mark: 1**

Response A

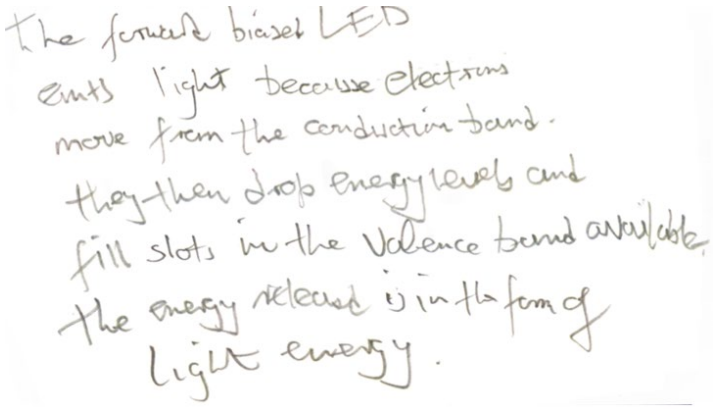
Marks

A semiconductor with other chemicals added to it.

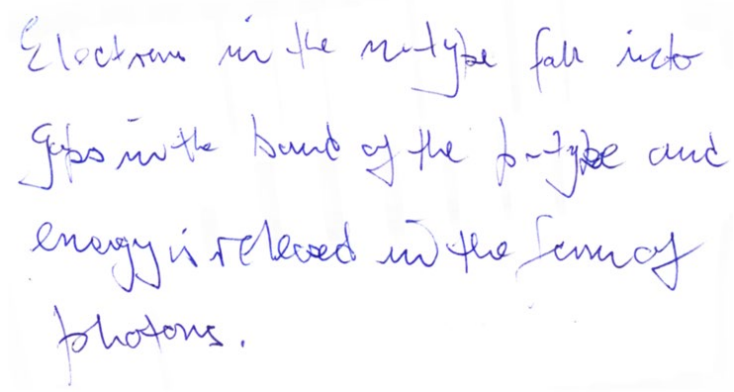
Q9(b)(iii)B **Maximum mark: 3**

Response A

Marks



Response B



9(a)(i)	A	2	1	The candidate has correctly substituted values but rounding of the intermediate calculation has resulted in an unacceptable final answer.
	B	2	1	The candidate has correctly substituted values but has given the final answer rounded to an unacceptable number of significant figures (correct final answer to 3 sig figs, acceptable final answers to 2, 4 or 5 sig figs).
9(a)(ii)	A	1	1	The candidate's explanation implies that the unbalanced force in the sideways direction is 0 N.
9(b)(i)	A	5	2	The candidate has selected an appropriate first relationship but has incorrectly substituted values (1.42×10^{-5} rather than 1.24×10^{-5}). The mark allocated for the selection of an appropriate second relationship can be awarded.
9(b)(ii)	A	3	2	The candidate has substituted values of I and d and correctly calculated the four values of $I \times d^2$.

Question	Candidate response	Max mark	Mark awarded	Commentary
				The statement 'as the results are all similar' does not sufficiently imply '$I \times d^2 = \text{constant}$'.
	B	3	2	The candidate has substituted values of I and d and correctly calculated the four values of $I \times d^2$. The calculation of a mean value is not a valid analysis when different values of the independent variable are used in the calculation.
9(b)(iii)(A)	A	1	1	The candidate's statement is acceptable.
9(b)(iii)(B)	A	3	1	The candidate's explanation does not specify either electrons moving from the conduction band of the n-type semiconductor towards the conduction band of the p-type semiconductor or photons being emitted. The statement 'electrons …drop energy levels and fill slots in the valence band' is sufficient for the second mark specified in the marking instructions to be awarded.
	B	3	0	The candidate's explanation does not refer either to conduction band or valence band. The mark for specifying the emission of photons is not accessible.