Question	Scheme	Marks	AOs
7(a)	All the even terms are positive and all the odd ones are negative. or $\sum_{r=1}^{2n}(-1)^r \mathrm{f}(r) = -\mathrm{f}(1)+\mathrm{f}(2)-\mathrm{f}(3)+\mathrm{f}(4)-\ldots$	M1	2.4
	$\sum_{r=1}^{2n}(-1)^r \mathrm{f}(r) = -\mathrm{f}(1)+\mathrm{f}(2)-\mathrm{f}(3)+\mathrm{f}(4)-\ldots-\mathrm{f}(2n-1)+\mathrm{f}(2n)$ $=\mathrm{f}(2)+\mathrm{f}(4)+\ldots+\mathrm{f}(2n)-\left(\mathrm{f}(1)+\mathrm{f}(3)+\ldots+\mathrm{f}(2n-1)\right)$ $=\sum_{r=1}^{n}\left(\mathrm{f}(2r)-\mathrm{f}(2r-1)\right)$ *	A1*	3.1a
		(2)	
(b)	$\sum_{r=1}^{2n} r\left((-1)^r+2r\right)^2 = \sum_{r=1}^{2n} r\left(1+4r(-1)^r+4r^2\right)$	M1	2.1
	$=\underline{\frac{1}{2}(2n)(2n+1)+4\frac{(2n)^2}{4}(2n+1)^2}+4\sum_{r=1}^{2n}(-1)^r r^2$	M1	1.1b
	$\sum_{r=1}^{2n}(-1)^r r^2 = \sum_{r=1}^{n}\left((2r)^2-(2r-1)^2\right)$	M1	3.1a
	$\sum_{r=1}^{2n} r\left((-1)^r+2r\right)^2 = n(2n+1)+4n^2(2n+1)^2+4\underline{\left(4\frac{n}{2}(n+1)-n\right)}$	B1	1.1b
	$=n(2n+1)+4\left(n(2n+1)\right)^2+4n(2n+1)$ $=n(2n+1)\left(1+4n(2n+1)+4\right)$	dM1	2.1
	$=n(2n+1)\left(8n^2+4n+5\right)$ *	A1*	1.1b
		(6)	
(c)	$\sum_{r=14}^{50} r\left((-1)^r+2r\right)^2 = \sum_{r=1}^{50} r\left((-1)^r+2r\right)^2 - \sum_{r=1}^{13} r\left((-1)^r+2r\right)^2$	M1	1.1b
	$=\sum_{r=1}^{50} r\left((-1)^r+2r\right)^2 - \sum_{r=1}^{12} r\left((-1)^r+2r\right)^2 - 13\times 25^2$ or $=\sum_{r=1}^{50} r\left((-1)^r+2r\right)^2 - \sum_{r=1}^{14} r\left((-1)^r+2r\right)^2 + 14\times 29^2$	M1	3.1a
	$=25\times 51\times 5105-6\times 13\times 317-13\times 25^2$ $(=6508875-24726-8125)$ or $25\times 51\times 5105-7\times 15\times 425+14\times 29^2$ $(=6508875-44625+11774)$	M1	2.1
	$=6476024$	A1	1.1b
		(4)	
		(12 marks)	

Notes:

(a)

M1: This mark is for stating that all the odd terms are negative (or subtracted) and all the even terms are positive (or added) or for showing this by writing down at least 4 terms as above. May be achieved via rhs e.g. $\sum_{r=1}^{n}(\mathrm{f}(2r)-\mathrm{f}(2r-1))=\mathrm{f}(2)-\mathrm{f}(1)+\mathrm{f}(4)-\mathrm{f}(3)+...$

A1*: A full and convincing argument that shows the equivalence of both sides of the equation. E.g. clearly demonstrates how the terms separate as $\mathrm{f}(2)+\mathrm{f}(4)+...+\mathrm{f}(2n)$ for the even powers and $\mathrm{f}(1)+\mathrm{f}(3)+...+\mathrm{f}(2n-1)$ for the odd powers and concludes $\sum_{r=1}^{n}(\mathrm{f}(2r)-\mathrm{f}(2r-1))$*

Need to see:

- the even terms grouped as e.g. $\mathrm{f}(2)+\mathrm{f}(4)+...+\mathrm{f}(2n)$
- the odd terms grouped as e.g. $\mathrm{f}(1)+\mathrm{f}(3)+...+\mathrm{f}(2n-1)$
- a conclusion

See below for some examples.

(b)

M1: Expands summand fully and applies $(-1)^{2r}=1$ or $r(-1)^{2r}=r$ at some point in their solution. Need not split the summation for this mark, $\sum r\left(1+k(-1)^r r+mr^2\right)$ can be accepted where k and m are 2 or 4.)

M1: Applies the correct formulae for sum of integers and sum of cubes to the r and mr^3 terms with $2n$

M1: Applies result of part (a) to the $(-1)^r$ term. Condone minor slips but the structure should be correct e.g.

$\lambda\sum_{r=1}^{2n}(-1)^r r^2=\sum_{r=1}^{n}\left(\alpha(2r)^2-\beta(2r-1)^2\right)$ but **not** e.g. $\lambda\sum_{r=1}^{2n}(-1)^r r^2=\sum_{r=1}^{n}\left(\alpha(2r)^2-\beta\left((2r)^2-1\right)\right)$, $\alpha,\beta>0$

B1: Correct expression for $4\sum_{r=1}^{2n}(-1)^r r^2$ which may be unsimplified e.g. $4\left(4\frac{n}{2}(n+1)-n\right)$ as shown or e.g. $8n^2+4n$, $\frac{16}{2}n(n+1)-4n$, etc. **Depends on previous method mark.**

dM1: Depends on all previous M marks. Takes out a factor of $n(2n+1)$ from a quartic expression. To score this mark, there must be a factor of n and an obvious factor of $(2n+1)$ if they leave the expressions inside the outer brackets factorised. However, this mark can be scored if they expand fully, take out a factor of n and then attempt to e.g. divide by $(2n+1)$ or e.g. use inspection to determine the quadratic factor. Must reach at least $=n(2n+1)\left(An^2+...n\right)$ where A is the coefficient of their cubic expression.

A1*: Correct answer obtained with no errors seen and suitable intermediate steps shown. Note that it is acceptable to go from $n\left(16n^3+16n^2+14n+5\right)$ to $n\left(2n+1\right)\left(8n^2+4n+5\right)$

(c)

M1: Attempts to split the sum to a difference upper limit 50 and lower limit 13. May be implied. Condone e.g. $\sum_{r=14}^{50}r\left((-1)^r+2r\right)^2=\sum_{r=1}^{50}\mathrm{f}(r)-\sum_{r=1}^{13}\mathrm{f}(r)$ or even $\sum_{r=14}^{50}r\left((-1)^r+2r\right)^2=\sum_{r=1}^{50}-\sum_{r=1}^{13}$

M1: Splits expression with **even** upper limits for both sums and evaluates an appropriate balancing term. The balancing term must be correct for their method but ignore whether it is added or subtracted for this mark.

M1: Attempts to use the result from (b) at least once **correctly** with an integer – so using $n = 25$ with upper limit 50, or $n = 6$ with upper limit 12 e.g. $25\times51\times5105$ or $6\times13\times317$. **Use of their upper limits in the formula is M0**

A1: 6476024 from correct work. Question says "hence" so use of the result from (b) must be clear.