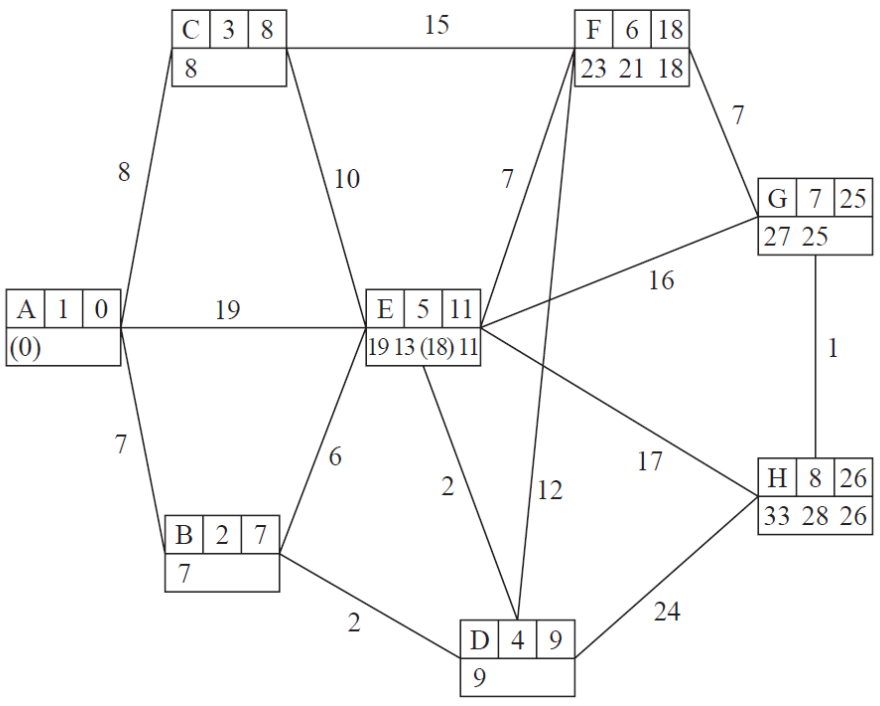
Question Number	Scheme	Marks
5. (a)	Pair the odd nodes: C, D **or** repeated arcs are CF, FG, DG	B1
	Time = 82 + 7 = 89	B1
	e.g. route GDGJHEADCABEFBCFCGFG	B1 **(3)**
(b)	BC + DG = B(F)C + DG = 6 + 3 = 9*	M1 A1
	BD + CG = B(FG)D + C(F)G = 11 + 4 = 15	A1
	BG + CD = B(F)G + C(FG)D = 8 + 7 = 15	A1
	Repeat arcs: BF, CF, DG	A1 **(5)**
(c)	Route starting from G is quicker	B1
	e.g. difference = (82 + 9) – 89 = 2 or 9 – 7 = 2	B1 **(2)**
		10 marks

Notes for Question 5

a1B1: cao (correctly stating the two odd nodes **or** correct repeated arcs stated) – so must either state that C and D are odd **or** state the arcs CF, FG, DG only, but B0 if only stating C and D or CD (without mention of 'odd')
a2B1: cao (89)
a3B1: Correct route: checks – starts and finishes at G, 20 nodes, CF, FG and DG repeated, A(2), B(2), C(3), D(2), E(2), F(3), G(4), H(1), J(1)

b1M1: Correct three distinct pairings of the correct four odd nodes B, C, D and G
b1A1: Any one row correct including pairing **and** total
b2A1: Any two rows correct including pairings **and** totals
b3A1: All three rows correct including pairings **and** totals
b4A1: cao - correct arcs clearly stated and not just in their working as BF, CF and DG – must be these arcs. Do not accept BC, BFC or BC via F

c1B1: cao (oe e.g. B to G is slower) – dependent on the correct repeats arcs (possibly implied) in (a) and (b) **or** clearly implied in (c) (e.g. correct values compared in this part) – must be clear that it is the route starting at G which is quicker
c2B1: cao (difference of 2 **or** comparing 89 and 91 **or** comparing 7 with 9)

6.(a)		M1 A1 (ABCD) A1 (EF) A1ft (GH) dM1 A1 **(6)**

Question Number	Scheme	Marks

	A	B	C	D	E	F	G	H
A	-	**7**	**8**	**9**	**11**	**18**	**25**	**26**
B	**7**	-	14	2	4	11	18	19
C	**8**	14	-	12	10	15	22	23
D	**9**	2	12	-	2	9	16	17
E	**11**	4	10	2	-	7	14	15
F	**18**	11	15	9	7	-	7	8
G	**25**	18	22	16	14	7	-	1
H	**26**	19	23	17	15	8	1	-

(b)	NNA: A – B – D – E – F – G – H – C – A	B1
	7 + 2 + 2 + 7 + 7 + 1 + 23 + 8 = 57 (km)	B1 **(2)**
(c)(i)	Prim (starting at C): CE, DE, BD, EF, FG, GH	M1 A1
	RMST weight = 10 + 2 + 2 + 7 + 7 + 1 = 29	
(c)(ii)	29 + 7(AB) + 8(AC) = 44 (km)	M1 A1 **(4)**
(d)	44 $\leqslant$ optimal distance $\leqslant$ 57	B2, 1, 0 **(2)**
		14 marks

Notes for Question 6

In (a) it is important that all values at each node are checked very carefully – the order of the working values must be correct for the corresponding A mark to be awarded e.g. at F the working values must be 23 21 18 in that order (so 23 18 21 is incorrect). It is also important that the order of labelling is checked carefully. The order of labelling must be a strictly increasing sequence – so 1, 2, 3, 3, 4, … will be penalised once (see notes below) but 1, 2, 3, 5, 6, … is fine. Errors in the final values and working values are penalised before errors in the order of labelling

Question Number	Scheme	Marks
a1M1: Any larger working value replaced by any smaller working value at at **least two nodes** except A, B, C and D **a1A1:** All values at A, B, C and D correct and the working values in the correct order. Condone lack of a zero as a working value at A **a2A1:** All values at E and F correct and the working values in the correct order. Penalise order of labelling only once per question (so E and F must be labelled in that order and E must be labelled after D) **a3A1ft:** All values at G and H correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question. To follow through G check that the working values at G follow from the candidate's final values for the nodes that are directly attached to G (which are E, F and H). For example, **if** correct then the order of labelling of nodes E, F and H are 5, 6 and 8 respectively so the working values at G should come from E and F in that order. The first working value at G should be 18 (the Final value at F) + 7 (the weight of the arc FG) and the second working value at G should be 11 (the Final value at E) + 16 (the weight of the arc EG). Repeat the process for H (which will have working values from D, E and G with the order of these nodes determined by the candidate's order of labelling at D, E and G) **a2M1:** Correct entries in the table following through their final values – dependent on the previous M mark (need only fill in either the A row or A column) **a4A1:** cao **b1B1:** Correct nearest neighbour route starting and finishing at A (A – B – D – E – F – G – H – C – A) **b2B1:** cao (57) on length of route **ci1M1:** First three arcs (CE, DE, BD) **or** all 7 nodes {C, E, D, B, F, G, H} correctly chosen in order. If any explicit rejections seen then M1only in (c)(i). Order of nodes may be seen at the top of the matrix/table {4, 1, 3, 2, 5, 6, 7}. Award M0 for a correct tree with no working. Award M1 only for the first three arcs (oe) selected correctly if starting at a different node than C. If correct values circled in the table but no indication of order of selection then M0 **ci1A1:** cso – all **arcs** correctly **stated** and chosen in the correct order (with no additional arcs). They must be considering arcs for this mark (do not accept a list of nodes or numbers across the top of the matrix unless the correct list of arcs (in the correct order) is also seen). If AB and AC added explicitly in (c)(i) then A0 but can score both marks in (c)(ii) **cii2M1:** Weight of RMST + 7 + 8 (two smallest arcs incident to A) with $19 \leqslant \text{RMST} \leqslant 39$ (if clearly not six arcs in RMST then M0). Give bod if 15 is added to the total of six values circled in the table provided those six values sum to a value between 19 and 39 inclusive **cii2A1:** cao (44) – if correct RMST stated in (c)(i) followed by 44 (with no additional working) then award M1A1 in (c)(ii). This mark is dependent on Prim's algorithm being used to find the RMST (allow this mark if rejections seen in (c)(i) when applying Prim). So in (c) M1A0M1A1 is possible e.g. if only stating the node (instead of the arc) selection in order when applying Prim. If the correct six values are circled in the table and added to 15 to give 44 but the order of arc/node selection is not stated (so no indication that Prim has been applied) then A0 (as the qu. says, 'Hence…') **d1B1: Any** indication of an interval from their answer to **(c)(ii)** to their answer to **(b)** with one value correct (e.g. $44 \sim 57$ scores B1 but $57 \sim 44$ or $57 \leqslant$ optimal distance $\leqslant 44$ scores B0). **If correct route seen in (b) but the upper bound not stated in (b) allow recovery in part (d) it stated here (but still withold the second mark in (b)).** **d2B1:** cao ($44 \leqslant$ optimal distance $\leqslant 57$) including correct inequalities (allow $44 <$ optimal distance $\leqslant 57$) – allow interval notation e.g., [44, 57] or (44, 57]	
7.(a)	Minimise $(P=)9x+12y+16z$	B1
	$x+y+z \geqslant 40$	B1
	$z \geqslant 2y$	B1
	$\frac{3}{5}(x+y+z) \geqslant x$ simplifies to $2x \leqslant 3y+3z$	M1 A1
	$x+1.5y+2.5z \leqslant 75$ simplifies to $2x+3y+5z \leqslant 150$	M1 A1
	$(x \geqslant 0, y \geqslant 0, z \geqslant 0)$	**(7)**
(b)	$9x+12y+16(45-x-y)$	M1