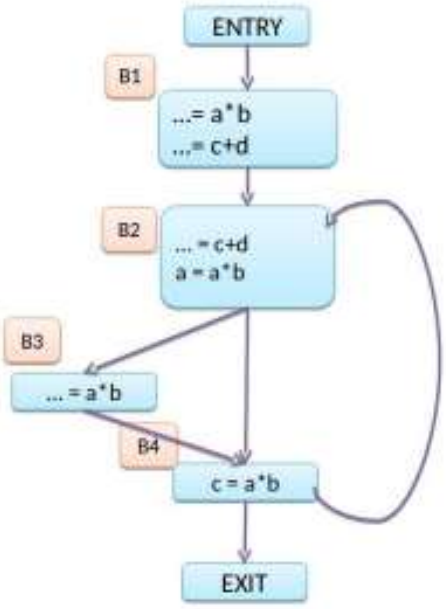
r2 = r0 + r1
r4 = r2 + r2

For next two questions: Consider the following CFG



Q150. **[MSQ]**

Which of the following is/are correct gen and kill sets of basic blocks for Available expression analysis?

(A) For basic block B1, Gen = {a*b, c + d}, Kill = {}

(B) For basic block B2, Gen = {c + d}, Kill = {a*b}

(C) For basic block B3, Gen = {a*b}, Kill = {}

(D) For basic block B4,Gen = {a*b}, Kill = {c + d}

Answer: a, b, c, d

Solution:

BB	GEN	KILL
B1	{a*b, c+d}	{ }
B2	{c+d}	{a*b}
B3	{a*b}	{}
B4	{a*b}	{c+d}

Q151. **[MSQ]**

Which of the following is/are correct IN and OUT sets of basic blocks for Available expression analysis?

(A) For basic block B1, IN = {}, OUT = {a*b, c + d}

(B) For basic block B2, IN = {a*b}, OUT = { a*b, c + d }

(C) For basic block B3, IN = {c + d}, OUT = {a*b, c + d}

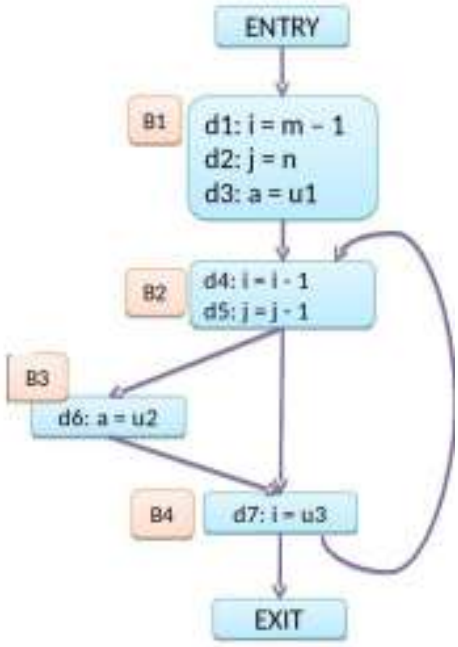
(D) For basic block B4, IN = {c + d}, OUT = {a*b, c + d}

Answer: a, b, c

Solution:

Pass#	Pt	B1	B2	B3	B4
Init	IN	-	-	-	-
	OUT	$\mathcal{U}$	$\mathcal{U}$	$\mathcal{U}$	$\mathcal{U}$
1	IN	∅	a*b, c+d	c+d	c+d
	OUT	a*b, c+d	c+d	a*b, c+d	a*b
2	IN	∅	a*b	c+d	c+d
	OUT	a*b, c+d	c+d	a*b, c+d	a*b
3	IN	∅	a*b	c+d	c+d
	OUT	a*b, c+d	c+d	a*b, c+d	a*b

For next two questions: Consider the following CFG



Q152. **[MSQ]**

If Gen (B) and Kill (B) represent the Gen set and Kill set of basic block B, respectively. Which of the following options is/ are correct about gen and kill sets of basics blocks for reaching definition analysis?

(A) Gen (B2) = Kill (B2) ∪ Kill (B3) ∪ Kill (B4)

(B) Gen (B1) – (Kill (B2) ∪ Kill (B3) ∪ Kill (B4)) = ∅

(C) Kill (B2) ∩ Kill (B1) = Gen (B4) – Kill (B4)

(D) Kill (B1) = Gen (B2) ∪ Gen (B3) ∪ Gen (B4)

Answer: b, c, d

Solution

BB	GEN	KILL
B1	{d1, d2, d3}	{d4, d5, d6, d7}
B2	{d4, d5}	{d1, d2, d7}
B3	{d6}	{d3}
B4	{d7}	{d1, d4}

Q153. **[MSQ]**

If IN (B) and OUT (B) represent the IN set and OUT set of basic block B, respectively. Which of the following options is/ are correct about IN and OUT sets of basics blocks for reaching definition analysis after 3rd Pass?

(A) |OUT (B2) ∩ OUT (B3)| = |OUT (B4) - OUT (B1)|

(B) IN (B3) = IN (B4)

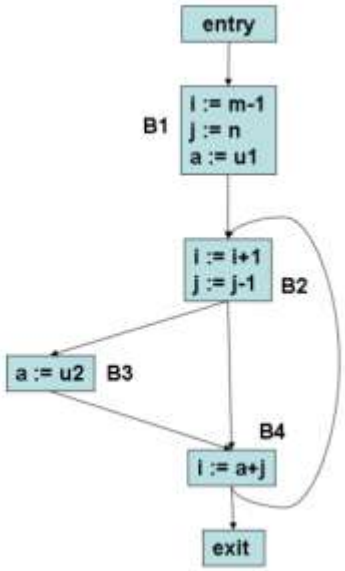
(C) OUT (B3) = IN (B4)

(D) IN (B2) ∪ IN (B1) = {d1, d2, d3, d5, d6, d7}

Answer: A, B, D
Solution:

Pass#	Pt	B1	B2	B3	B4
Init	IN	-	-	-	-
	OUT	∅	∅	∅	∅
1	IN	∅	d1, d2, d3	d3, d4, d5	d3, d4, d5, d6
	OUT	d1, d2, d3	d3, d4, d5	d4, d5, d6	d3, d5, d6, d7
2	IN	∅	d1, d2, d3, d5, d6, d7	d3, d4, d5, d6	d3, d4, d5, d6
	OUT	d1, d2, d3	d3, d4, d5, d6	d4, d5, d6	d3, d5, d6, d7
3	IN	∅	d1, d2, d3, d5, d6, d7	d3, d4, d5, d6	d3, d4, d5, d6
	OUT	d1, d2, d3	d3, d4, d5, d6	d4, d5, d6	d3, d5, d6, d7

For next Eight questions: Consider the following CFG



Q154. Which of the following is correct use and define sets of basics block B1 for live variable analysis?

(A) Use = { m, n}, Def = {i, j, a }

(B) Use = { m, n, u1}, Def = {i, j }

(C) Use = {m, n }, Def = {i, j }

(D) Use = { m, n, u1 }, Def = { i, j, a}

Answer :-D

Q155.	Which of the following is correct use and define sets of basics block B2 for live variable analysis? (A) Use = {i,j }, Def = {i,j } (B) Use = { i,j}, Def = {i } (C) Use = {i,j }, Def = { } (D) Use = {i,j }, Def = {j } Answer :-C
Q156.	Which of the following is correct use and define sets of basics block B3 for live variable analysis? (A) Use = {u2 }, Def = {a } (B) Use = {u2 }, Def = {u2,a } (C) Use = { a,u2}, Def = {a } (D) Use = {a }, Def = { u2} Answer :-A
Q157.	Which of the following is correct use and define sets of basics block B4 for live variable analysis? (A) Use = {a, j, i }, Def = {i } (B) Use = { a, j}, Def = {i } (C) Use = {a, j, i }, Def = {a, j, i } (D) Use = {a, j, i }, Def = { i, j} Answer :-B
Q158.	Which of the following is correct in and out sets of basics block B1 for live variable analysis? (A) In = {m,n,u1}, Out = {i,j,u2,a} (B) In = {m,n}, Out = {i,j,u2,a} (C) In = {m,n,u1}, Out = {i,j,u2} (D) In = {m,n}, Out = {i,j,u2} Answer :-A
Q159.	Which of the following is correct in and out sets of basics block B2 for live variable analysis? (A) In = {i,j,a}, Out = {a,j,u2} (B) In = {i,j,a,u2}, Out = {a,j,u2} (C) In = {i,j,a}, Out = {a,j,u1} (D) In = {i,j,a,u1}, Out = {a,j,u2} Answer :-B
Q160.	Which of the following is correct in and out sets of basics block B3 for live variable analysis?

(A) In = {j,u2}, Out = {a,j,u2}

(B) In = {i,u2}, Out = {a,j,u2}

(C) In = {i,j,u2}, Out = {a,j,u2}

(D) In = {i,j}, Out = {a,j,u2}

Answer :-A

Q161. Which of the following is correct in and out sets of basics block B4 for live variable analysis?

(A) In = {a,j,u2}, Out = {a,j,u2}

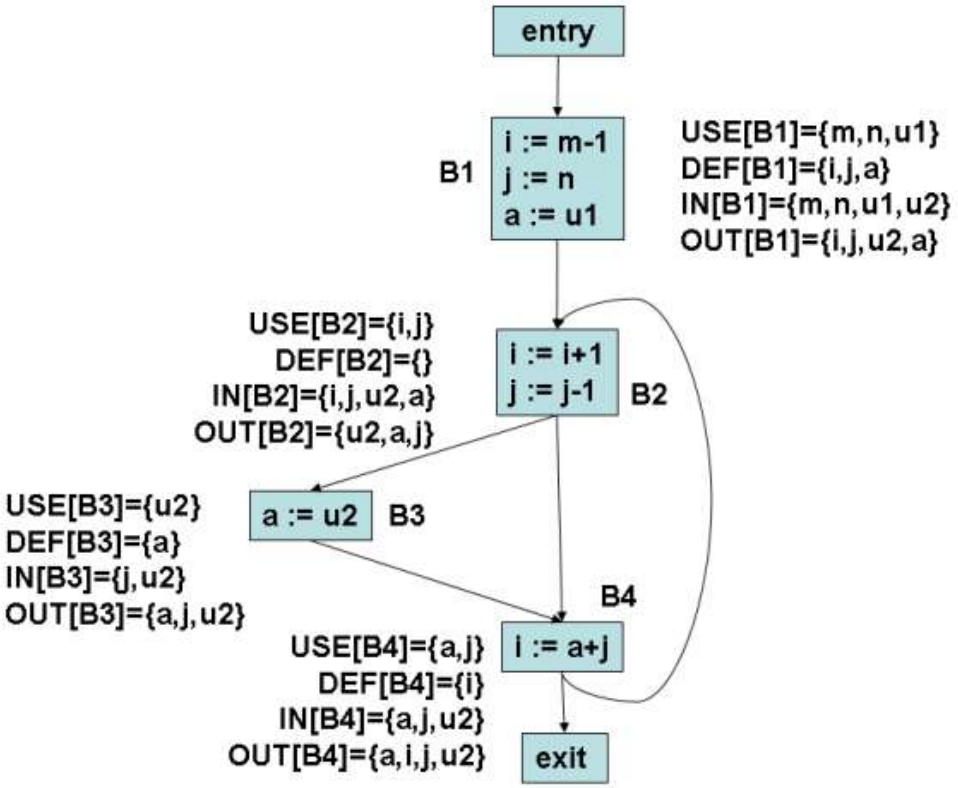
(B) In = {a,j,u2}, Out = {a,i,j,u2}

(C) In = {a,j,u2}, Out = {a,i,u2}

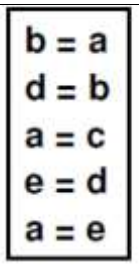
(D) In = {a,i,u2}, Out = {a,i,j,u2}

Answer :-b

Solution



For next two questions: Consider the following basic block for live variables:



Q162. What is USE for the basic block?

(A) {a}

(B) {b,c}

(C) {e, d}

(D) { a, c }

Answer:- D

Solution

Use(B)={a,c}

Def (B)={b,d,e,a}

Q163. What is DEF for the basic block?

(A) {a,b,d}

(B) {c, d, b}

(C) { a, b, d, e }

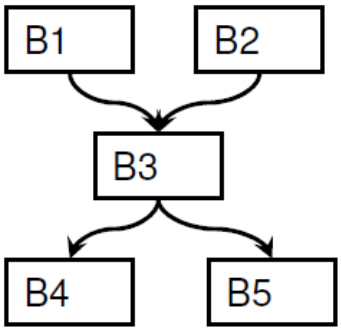
(D) {a, c}

Answer:- C

Solution

Def(B)={a,b,d,e}

Consider the following control flow graph for next three questions



Assume you are given IN/OUT for B1, B2, B4, B5, and GEN/KILL for B3.

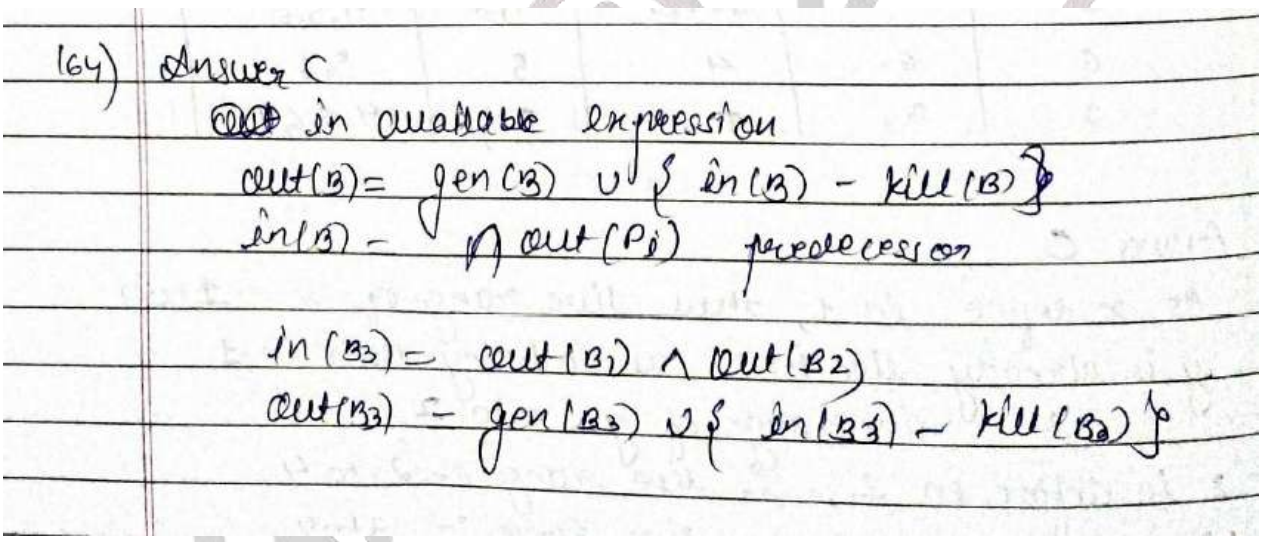
Q164. What is the forward data-flow problem for available expression for basic block B3?

(A) IN(B3) = OUT(B1) ∧ OUT(B2) , OUT(B3) = GEN(B3) ∩(IN(B3) – KILL(B3))

(B) IN(B3) = OUT(B1) ∨ OUT(B2), OUT(B3) = GEN(B3) U (IN(B3) – KILL(B3))

(C) IN(B3) = OUT(B1) ∧ OUT(B2), OUT(B3) = GEN(B3) U (IN(B3) – KILL(B3))

(D) IN(B3) = OUT(B1) ∨ OUT(B2) ,OUT(B3) = GEN(B3) ∩(IN(B3) – KILL(B3))



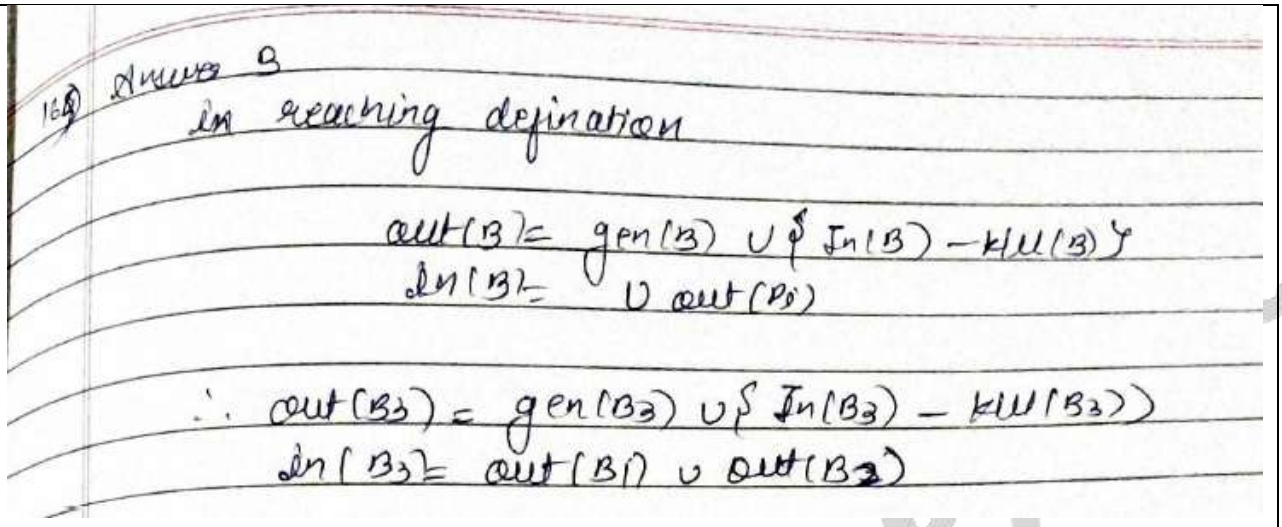
Q165. What is the forward data-flow problems for reaching definition for basic block B3 ?

(A) IN(B3) = OUT(B1) ∧ OUT(B2) , OUT(B3) = GEN(B3) ∩(IN(B3) – KILL(B3))

(B)IN(B3) = OUT(B1) ∨ OUT(B2), OUT(B3) = GEN(B3) U (IN(B3) – KILL(B3))

(C) IN(B3) = OUT(B1) ∧ OUT(B2), OUT(B3) = GEN(B3) U (IN(B3) – KILL(B3))

(D) IN(B3) = OUT(B1) ∨ OUT(B2) ,OUT(B3) = GEN(B3) ∩(IN(B3) – KILL(B3))



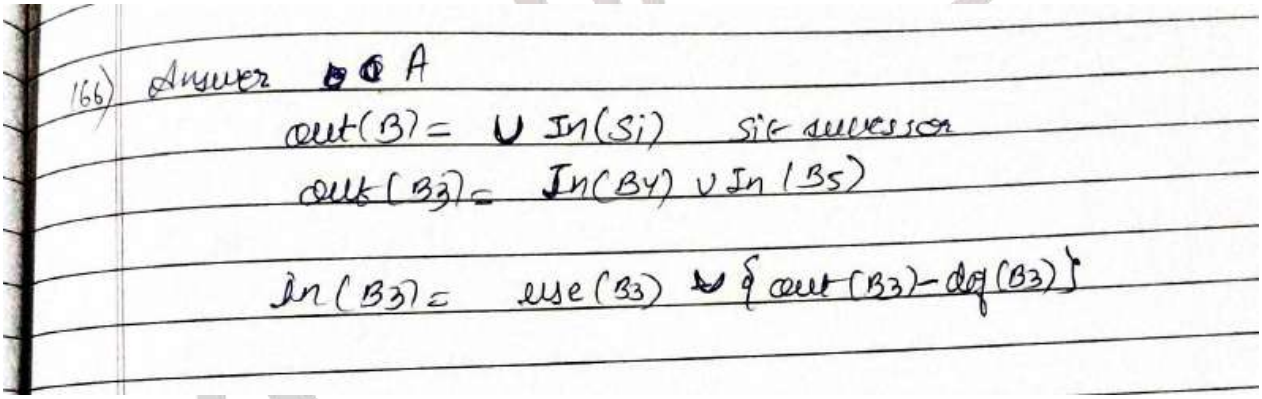
Q166. What is the backwards data-flow problems for B3 ?

(A) OUT(B3) = IN(B4) ∨IN(B5) , IN(B3) = USE(B3) U (OUT(B3) – DEF(B3))

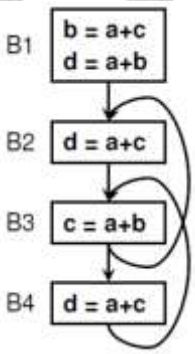
(B) OUT(B3) = IN(B4) ∧IN(B5), IN(B3) = USE (B3) ∩(OUT(B3) – DEF (B3))

(C) OUT(B3) = IN(B4) ∨IN(B5) , IN(B3) = USE (B3) ∩(OUT(B3) – DEF (B3))

(D) OUT(B3) = IN(B4) ∧IN(B5) ,IN(B3) = USE (B3) U (OUT(B3) – DEF (B3))



Consider the following control flow graph for available expressions



Q167. Calculate GEN/KILL for each basic block. Which of the following option is true?

(A)

	GEN	KILL
B1	a+c,a+b	a+b
B2	a+c	ϕ
B3	a+b	a+b
B4	a+c	ϕ

(B)

	GEN	KILL
B1	a+c,a+b	a+b
B2	a+c	ϕ
B3	a+b	a+c
B4	a+c	ϕ

(C)

	GEN	KILL
B1	a+c,a+b	a+c
B2	a+c	ϕ
B3	a+b	a+c
B4	a+c	ϕ

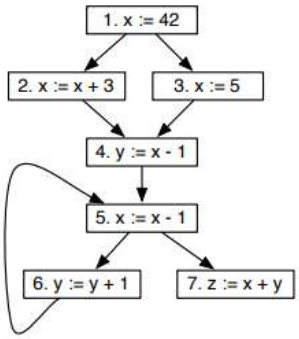
(D)

	GEN	KILL
B1	a+c,a+b	a+b
B2	a+c	ϕ
B3	a+b	a+c
B4	a+c	a+c

Answer: B

Solution
IN[B] = ∩ P a predecessor of B OUT[P];
OUT[B] =gen[B] ∪ [(IN[B] − kill[B]);

For next two questions consider the control-flow graph with numbers for each statement:



Q168. What are the sets of live variables at the beginning of each statement?

[Note: Write ∅ for the empty set, if necessary]

(A) 1 – ∅ , 2 – {x}, 3 – {x}, 4 – {x}, 5 – {x, y}, 6 – {x, y}, 7 – {x, y}
(B) 1 – ∅ , 2 – {x}, 3 – ∅, 4 – {x}, 5 – {x, y}, 6 – {x, y}, 7 – {x, y}
(C) 1 – ∅ , 2 – ∅, 3 – ∅, 4 – {x}, 5 – {x, y}, 6 – {x, y}, 7 – {x, y}
(D) 1 – ∅ , 2 – {x}, 3 – ∅, 4 – {x}, 5 – {y}, 6 – {x, y}, 7 – {x, y}

Answer: B

Solution:

Stmt	Live variables at beginning of stmt
1	∅
2	x
3	∅
4	x
5	x,y
6	x,y
7	x,y

Q169. What are the sets of reaching definitions at the end of each statement?
[Note: Write ∅ for the empty set, if necessary]

(a)

statement	Reaching Definition
1	1
2	2
3	3
4	2, 3
5	4, 5, 6
6	5, 6
7	4, 5, 6, 7

(b)

statement	Reaching Definition
1	1
2	2
3	3
4	2, 3, 4
5	4, 5, 6
6	4, 5, 6
7	4, 5, 6, 7

(c)

statement	Reaching Definition
1	1
2	2
3	3
4	2, 3, 4
5	4, 5, 6
6	5, 6
7	4, 5, 6, 7

(d)

statement	Reaching Definition
1	1
2	2
3	3
4	2, 3, 4
5	5, 6
6	5, 6
7	4, 5, 6, 7

169) Answer e

Block	gen(B)	kill(B)	in(B)	out(B)
1	1	2,3,5	ϕ	1
2	2	1,3,5	1	2
3	3	1,2,5	1	3
4	4	6	2,3	2,3,4
5	5	1,2,3	4,6	4,5,6
6	6	4	5	5,6
7	7	ϕ	5,4,6	4,5,6,7

Q170. What is the live range for each variable (x, y, z, w & v) in the following program?

```
0: ….
1: x = y + 1
2: z = x + y
3: w = load(x)
4: v = f(z, w)  // v is used later
5: ….
```

(A) x: 0-3, y: 0-2, z: 0-4, w: 0-4, v: 0-4

(B) x: 1-3, y: 1-2, z: 2-4, w: 3-4, v: 4-4

(C) x: 1-3, y: 0-2, z: 2-4, w: 3-4, v: 4-5

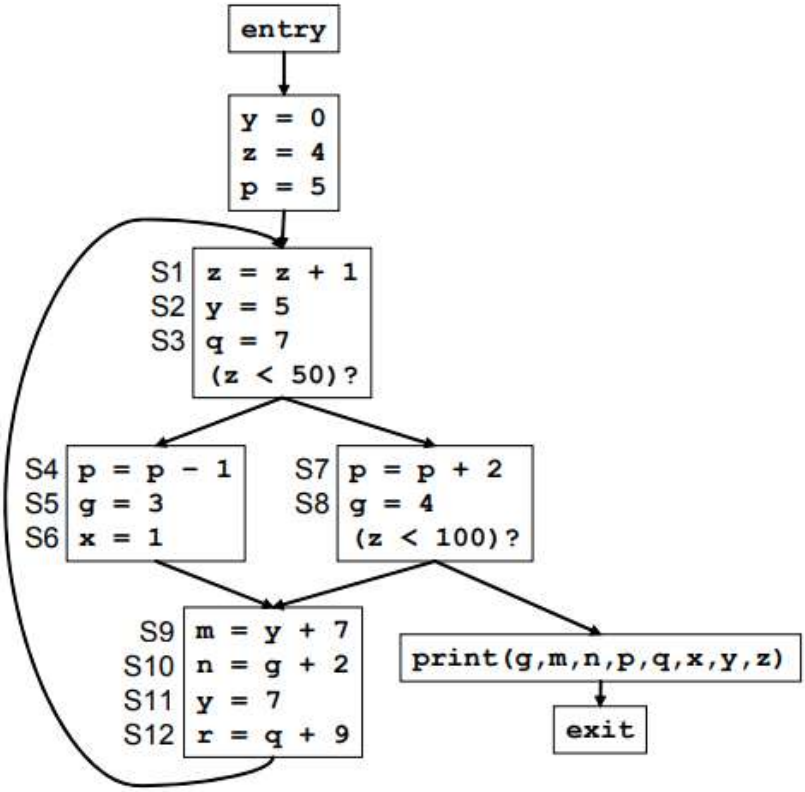
(D) None of the above

170) Answer C

As x define in 1, thus live range of x = 1 to 3
y is already live in 0, as it being used in 1
∴ live range of y = 0 to 2
z is define in 2, ∴ live range :- 2 to 4
w is define in 3, ∴ live range :- 3 to 4
v define in 4, and will be used later ∴ live range :- 4 to

Q171. **[MSQ]**

For the following code, find the loop invariant instruction(s) which can be moved to the pre-header by a loop-invariant code motion pass?



(A) S2 : y = 5

(B) S3 : q = 7

(C) S6: x = 1

(D) None of these

171) Answer B

a) S2 : y = 5, we can't put this outside loop, as y is changing in iterations.

b) S3 : q = 7 loop invariant, as it does not get updated in loop.

c) S6 : x = 1, this can't be loop invariant because there exist a path in which this value is not assigned to x and gets printed S1 → S2 → S3 → S7 → S8 → print.

d) False.