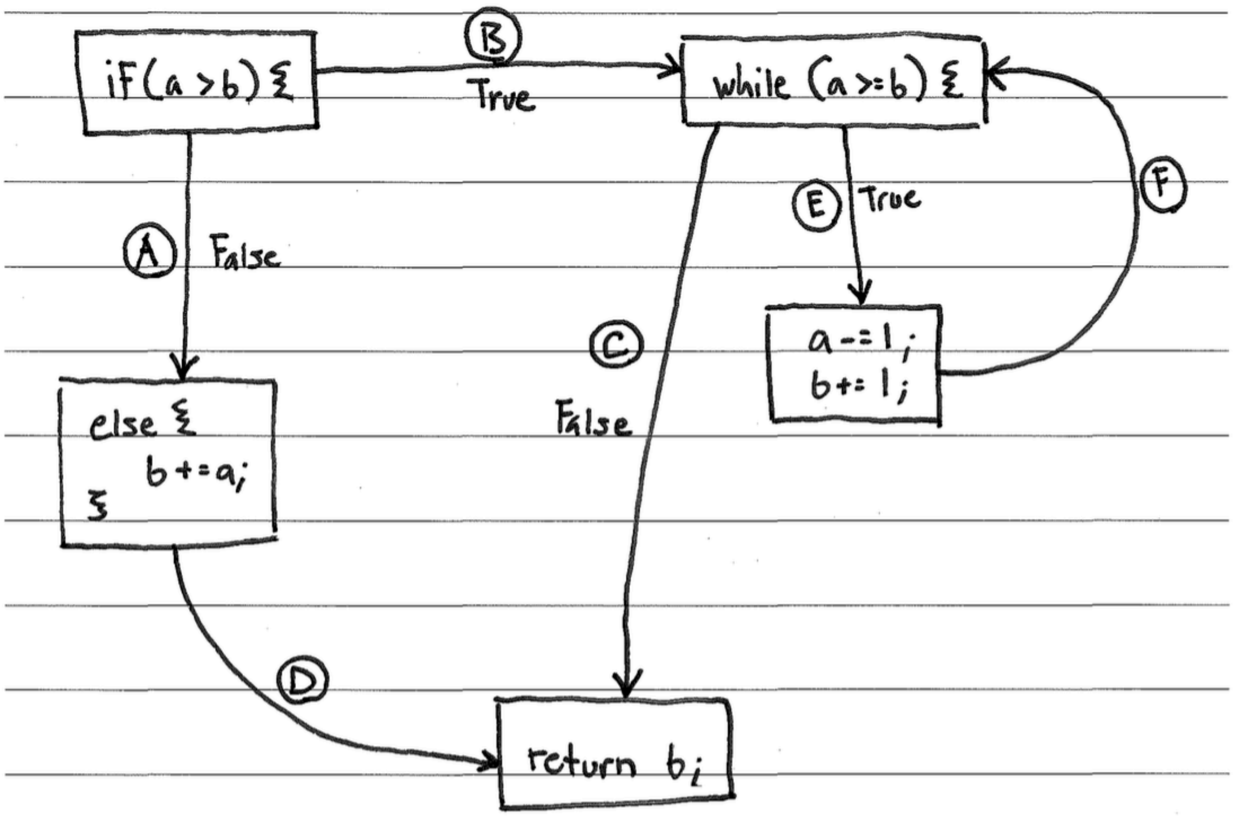
Problem: Draw a control flow diagram for this function. Label each edge with an uppercase letter.

```
int funWithNumbers(int a, int b) {
    if (a > b) {
        while (a >= b) {
            a -= 1;
            b += 1;
        }
    } else {
        b += a;
    }
    return b;
}
```

Solution:



if(a > b) {
B
True
while (a >= b) {
E
True
F
A
False
a -= 1;
b += 1;
C
False
else {
b += a;
}
D
return b;

Problem: Fill in the table below with a test suite that provides *path coverage* of the code from the previous question. Cover no more than 2 iterations of the loop. In the covers column, list the relevant labeled items in your CFG that each test case covers. If there is some part of the coverage that is impossible to cover, then list it in the covers column, and put "N/A" in the associated x and y cells. Some cells in the table may be left blank.

Input		Covers
x	y	

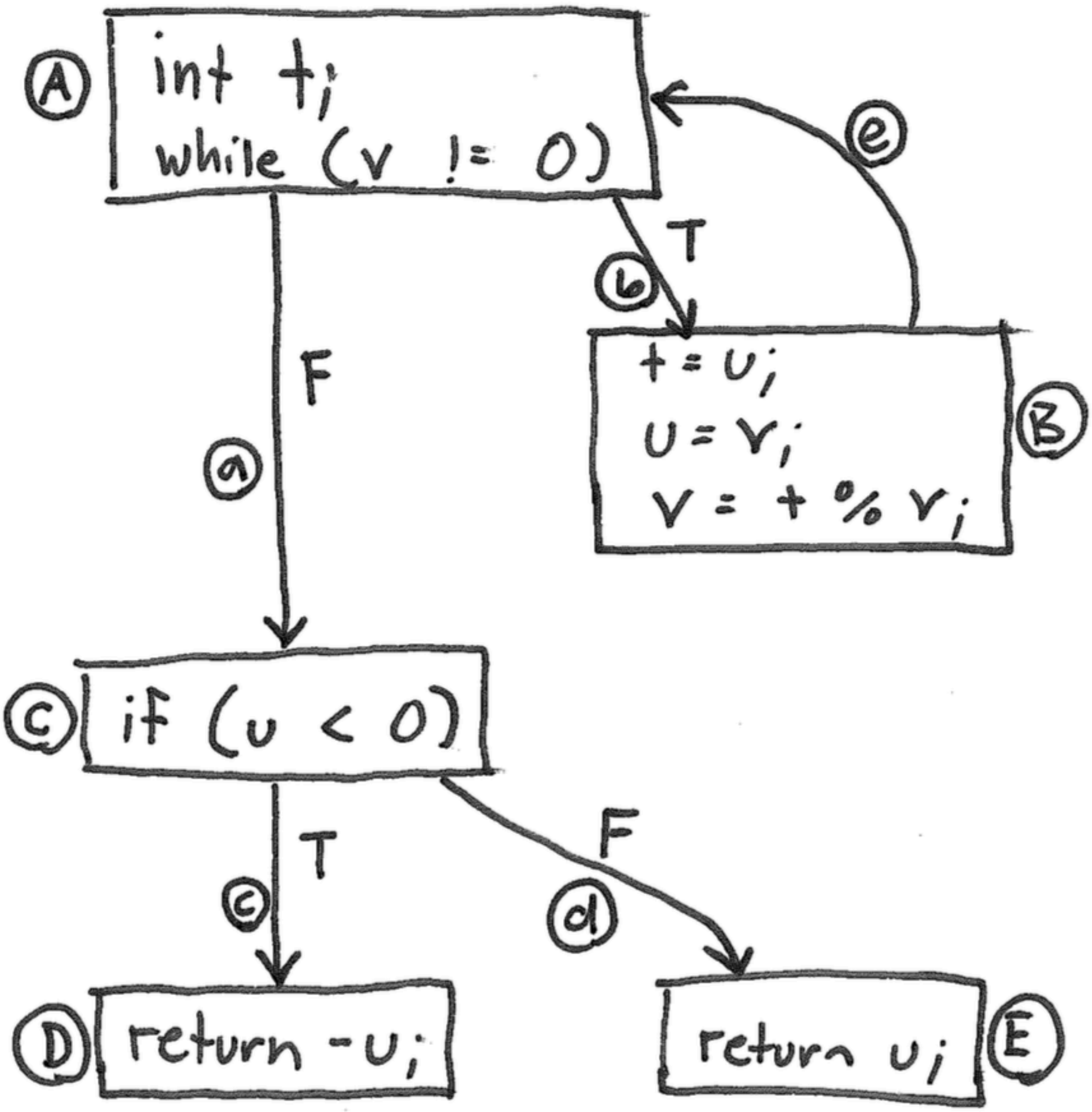
Solution:

Input		Covers
x	y	
1	2	AD
N/A	N/A	BC
1	0	BEFC
4	2	BEFEFC

Problem: Draw a control flow diagram for this function. Label each node in the graph with a capital letter, and label each edge with a lowercase letter.

```
int blammo(int u, int v) {
  int t;
  while (v != 0) {
    t = u;
    u = v;
    v = t % v; // Recall that % computes remainder of t/v
  }
  if (u < 0) { return -u; }
  return u;
}
```

Solution:



A
int t;
while (v != 0)
T
b
F
a
t = u;
u = v;
v = t % v;
B
e
C
if (u < 0)
T
c
F
d
D
return -u;
return u;
E

Problems:

1. Fill in the table below with a test suite that provides statement coverage of the “blammo” code. In the covers column, list the relevant labeled items in your CFG that each test case covers. Some cells in the table may be left blank.

Input		Covers
u	v	

2. Fill in the table below with a test suite that provides path coverage of the “blammo” code. Cover no more than 1 iteration of the loop. In the covers column, list the relevant labeled items in your CFG that each test case covers. Some cells in the table may be left blank.

Input		Covers
u	v	

Solutions:

1.

Input		Covers
u	v	
2	2	A, B, C, E
-1	0	A, C, D

2.

Input		Covers
u	v	
-1	0	a, c
0	0	a, d
-2	-2	b, e, a, c
2	2	b, e, a, d

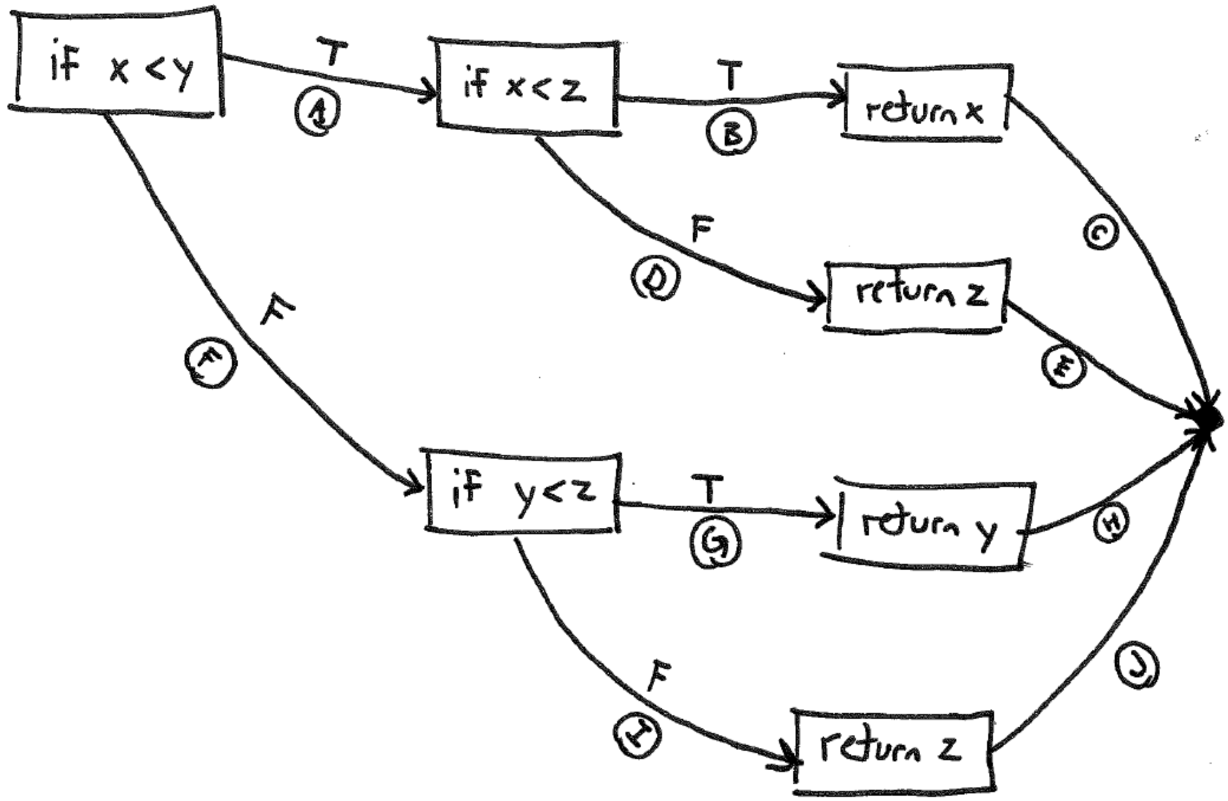
Paths:

a, c
a, d
b, e, a, c
b, e, a, d

Problem: Draw a control-flow graph for the following function. Label each edge in the graph with an uppercase letter.

```
def min_of_three(x, y, z)
  if x < y then
    if x < z then
      return x
    else
      return z
    end
  else
    if y < z then
      return y
    else
      return z
    end
  end
end
```

Solution:



if x<y
T
A
if x<z
T
B
return x
C
F
D
return z
E
F
F
if y<z
T
G
return y
H
F
I
return z
J

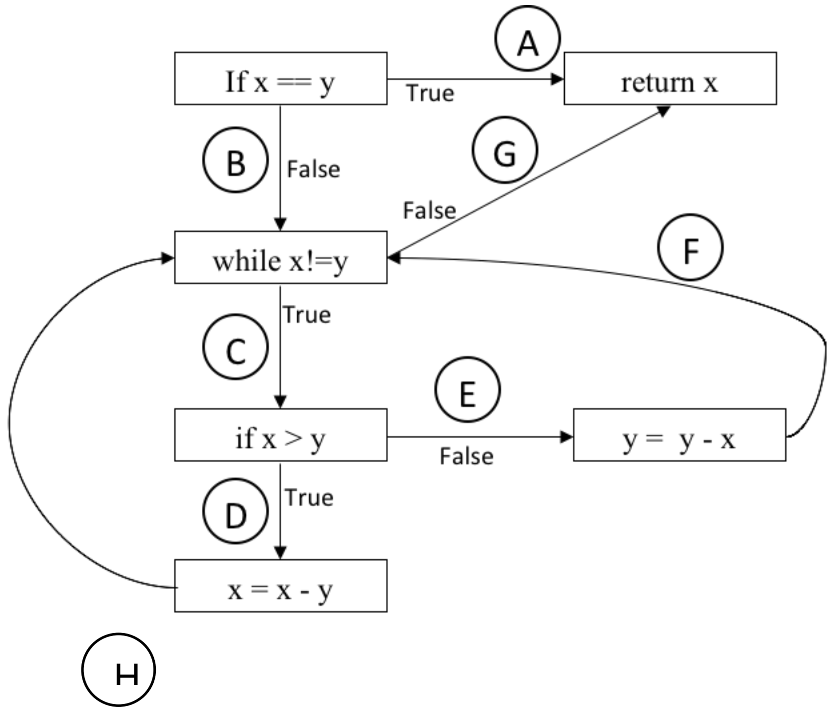
Problem: Fill in the table below with a test suite that provides path coverage of the `min_of_three` function from the previous question. In the covers column, list the relevant labeled edges in your CFG that each test case covers. Some cells in the table may be left blank.

Input			Expected Output	Covers
x	y	z		

Solution:

Input			Expected Output	Covers
x	y	z		
1	2	2	1	A, B, C
2	3	1	1	A, D, E
2	1	2	1	F, G, H
3	2	1	1	F, I, J

Consider the following control-flow graph for a `gcd` function in answering the questions below.



Problem: Fill in the table below with a test suite that provides condition coverage of the `gcd` function (see control-flow graph above). In the Covers column, list the relevant labeled edges in the CFG that each test case covers. Some cells in the table may be left blank.

Input		Expected Output	Covers
x	y		

Problem: Fill in the table below with a test suite that provides path coverage of the `gcd` function (see control-flow graph above). In the Covers column, list the relevant labeled edges in the CFG that each test case covers. Some cells in the table may be left blank. You need only cover executions that involve 1 iteration of the loop.

Input		Expected Output	Covers
x	y		

Solution: Condition Coverage

Input		Expected Output	Covers
x	y		
1	1	1	A
1	2	1	B, C, E, G
2	1	1	B, C, D, G
3	2		B, C, D, C, E, G

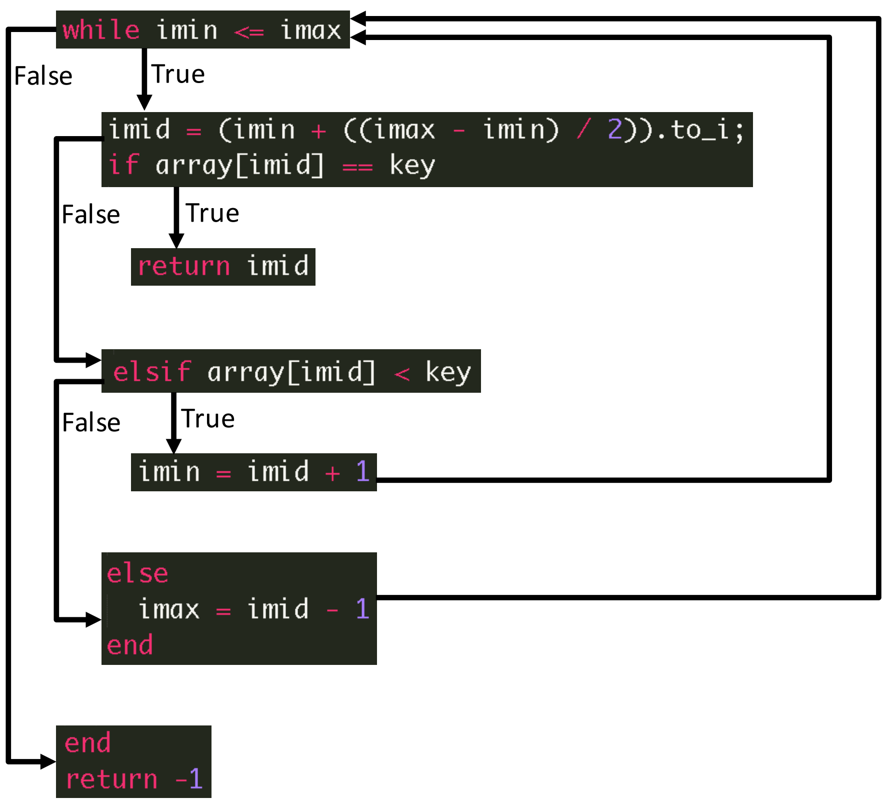
alternatively

Solution: Path Coverage

Input		Expected Output	Covers
x	y		
1	1	1	A
2	1	1	B, C, D, H, G
1	2	1	B, C, E, F, G
			B, G ← not possible

Consider this binary-search function and its associated control-flow graph.

```ruby
def binary_search(array, key, imin, imax)
  while imin <= imax
    imid = (imin + ((imax - imin) / 2)).to_i;
    if array[imid] == key
      return imid
    elsif array[imid] < key
      imin = imid + 1
    else
      imax = imid - 1
    end
  end
  return -1
end
```



Problems:

Consider the following test cases for the `binary_search` function.

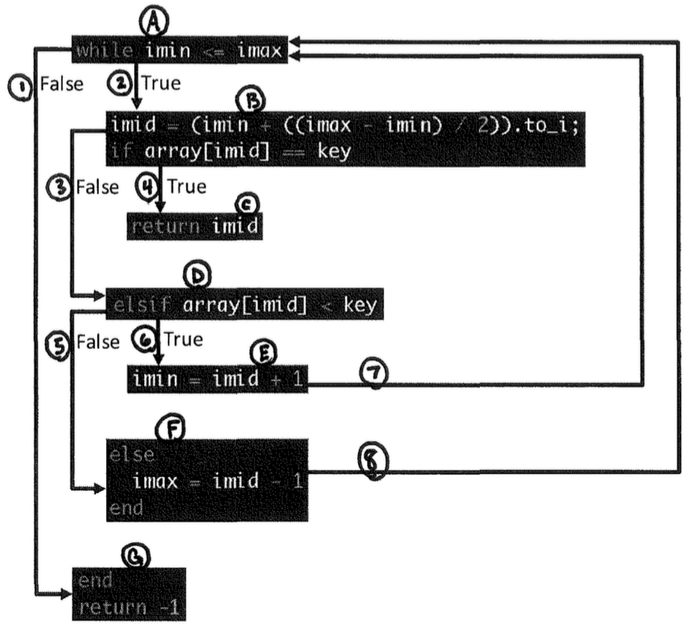
	array	key	imin	imax
a.	[1]	0	0	0
b.	[1]	1	0	0
c.	[1]	1	1	0
d.	[1, 2, 3]	1	0	2
e.	[1, 2, 3]	2	0	2
f.	[1, 2, 3]	3	0	2
g.	[1, 2, 3]	1	2	0
h.	[1, 2, 3]	2	2	0
i.	[1, 2, 3]	3	2	0

1. Select tests from the above to create a test suite that provides statement coverage of the `binary_search` function. Your suite should contain the minimum number of tests to provide the coverage.

2. Select tests from the above to create a test suite that provides condition coverage of the `binary_search` function. Your suite should contain the minimum number of tests to provide the coverage.

3. Select tests from the above to create a test suite that provides path coverage of the `binary_search` function. Cover only paths that contain one loop iteration or fewer (i.e., no path should enter the loop more than once). Your suite should contain the minimum number of tests to provide the coverage.

Solutions:



	array	key	imin	imax	Statements Covered	Edges Covered
a.	[1]	0	0	0	ABDFAG	23581
b.	[1]	1	0	0	ABC	24
c.	[1]	2	0	0	ABDEAG	23671
d.	[1, 2, 3]	1	0	2	ABDFABC	235824
e.	[1, 2, 3]	2	0	2	ABC	24
f.	[1, 2, 3]	3	0	2	ABDEABC	236724
g.	[1, 2, 3]	1	2	0	AG	1
h.	[1, 2, 3]	2	2	0	AG	1
i.	[1, 2, 3]	3	2	0	AG	1

1. a, F or c, d

(Need to cover statements A, B, C, D, E, F, G)

2. a, F or c, d

(Need to cover edges 1, 2, 3, 4, 5, 6)

3. (g|h|i), (b|e), c, a

(g|h|i): Any 1 of these; (b|e): Any 1 of these

Possible paths	Tests that cover
1	g, h, i
24	b, e
23671	c
23581	a

Problems:

Consider the following test cases for the binary_search function.

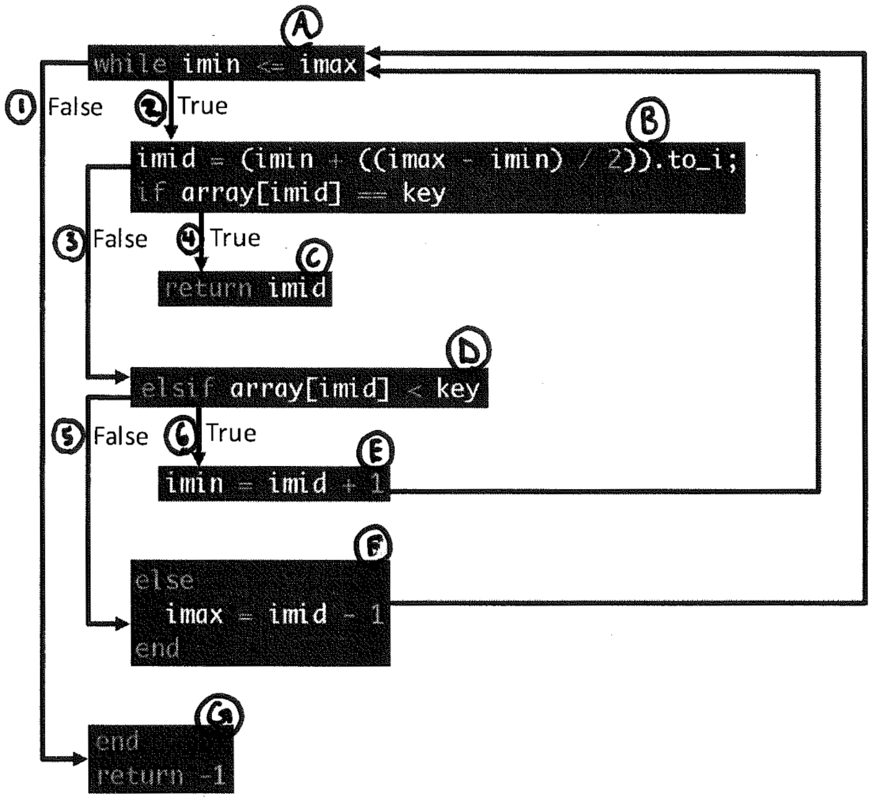
	array	key	imin	imax
a.	[0]	0	0	0
b.	[0]	1	0	0
c.	[0]	1	1	0
d.	[0]	-1	0	0

1. Select tests from the above to create a test suite that provides statement coverage of the binary_search function. Your suite should contain the minimum number of tests to provide the coverage.

2. Select tests from the above to create a test suite that provides condition coverage of the binary_search function. Your suite should contain the minimum number of tests to provide the coverage.

3. Select tests from the above to create a test suite that provides path coverage of the binary_search function. Cover only paths that contain one loop iteration or fewer (i.e., no path should enter the loop more than once). Your suite should contain the minimum number of tests to provide the coverage.

Solutions:



	array	key	imin	imax	Statements Covered	Conditions Covered
a.	[0]	0	0	0	A B C	2 4
b.	[0]	1	0	0	A B D E G	2 3 6 1
c.	[0]	1	1	0	A G	1
d.	[0]	-1	0	0	A B D F G	2 3 5 1

Path	Covered by
A G	c
A B C	a
A B D E A G	b
A B D F A G	d

1. a, b, d
2. a, b, d
3. a, b, c, d