1. Below are four graphs, each of which is defined by the sets of nodes, initial nodes, final nodes, edges, and defs and uses. Each graph also contains some test paths. Answer the following questions about each graph.

Graph II.
$N = \{1, 2, 3, 4, 5, 6\}$
$N_0 = \{1\}$
$N_f = \{6\}$
$E = \{(1,2), (2,3), (2,6), (3,4), (3,5), (4,5), (5,2)\}$
$def(1) = def(3) = use(3) = use(6) = \{x\}$
// Assume the use of x in 3 precedes the def
Test Paths:
$t1 = [1, 2, 6]$
$t2 = [1, 2, 3, 4, 5, 2, 3, 5, 2, 6]$
$t3 = [1, 2, 3, 5, 2, 3, 4, 5, 2, 6]$
$t4 = [1, 2, 3, 5, 2, 6]$

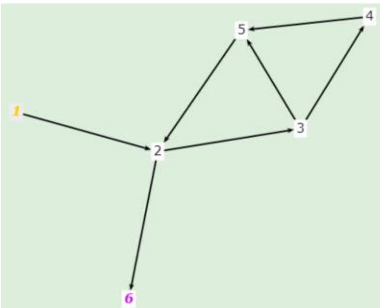
Graph III.
$N = \{1, 2, 3, 4, 5, 6\}$
$N_0 = \{1\}$
$N_f = \{6\}$
$E = \{(1,2), (2,3), (3,4), (3,5), (4,5), (5,2), (2,6)\}$
$def(1) = def(4) = use(3) = use(5) = use(6) = \{x\}$

Test Paths:
$t_1 = [1, 2, 3, 5, 2, 6]$
$t_2 = [1, 2, 3, 4, 5, 2, 6]$

(a) Draw the graph.
(b) List all of the du-paths with respect to x. (Note: Include all-du-paths, even those that are subpaths of some other du-path).
(c) Determine which du-paths each test path tours. Write them in a table with test paths in the first column and the du-paths they cover in the second column. For this part of the exercise, you should consider both direct touring and sidetrips.
(d) List a minimal test set that satisfies *all defs* coverage with respect to x. (Direct tours only.) Use the given test paths.
(e) List a minimal test set that satisfies *all uses* coverage with respect to x. (Direct tours only.) Use the given test paths.
(f) List a minimal test set that satisfies *all-du-paths* coverage with respect to x. (Direct tours only.) Use the given test paths.

Graph II

(a)



(b)

i	*[1, 2, 3]*
ii	*[1, 2, 6]*
iii	*[3, 4, 5, 2, 3]*
iv	*[3, 4, 5, 2, 6]*
v	*[3, 5, 2, 3]*
vi	*[3, 5, 2, 6]*

(c)

The numbers in the table below correspond to the du-paths in the previous table. The table indicates whether each test path tours each du-path with or without a sidetrip.

Test paths	direct	w/ sidetrip
t1 = [1, 2, 6]	ii	/
t2 = [1, 2, 3, 4, 5, 2, 3, 5, 2, 6]	i, iii, vi	/
t3 = [1, 2, 3, 5, 2, 3, 4, 5, 2, 6]	i, iv, v	/
t4 = [1, 2, 3, 5, 2, 6]	i, vi	/

Note that, for example, although t_2 does not tour path (v) with a sidetrip, it does tour path (v) with a detour.

(d)

This question has multiple possible answers. All test paths use the def in 1, and test paths $\{t_2\}$, $\{t_3\}$, $\{t_4\}$ each use the def in 3. Possible answers: $\{t_2\}$, $\{t_3\}$, or $\{t_4\}$.

(e)

This question only has two possible answers. $\{t_1\}$ *is required for the def in* 1 *to reach the use in* 6. *Either* t_2 *or* t_3 *is required for the def in* 3 *to reach the use in* 3. *Possible answers:* $\{t_1, t_2\}$ *or* $\{t_1, t_3\}$.

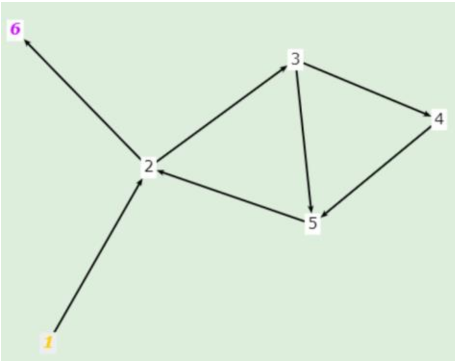
(f)

This question has one possible answer: $\{t_1, t_2, t_3\}$. t_1 *is required for path (ii).* t_2 *is required for path (iii).* t_3 *is required for path (iv). Since* t_1, t_2, *and* t_3 *together tour all six du-paths,* t_4 *is not needed.*

==

Graph III

(a)



(b)

i	*[1, 2, 3]*
ii	*[1, 2, 3, 5]*
iii	*[1, 2, 6]*
iv	*[4, 5]*
v	*[4, 5, 2, 3]*
vi	*[4, 5, 2, 6]*

(c)

The numbers in the table below correspond to the du-paths in the previous table. The table indicates whether each test path tours each du-path with or without a sidetrip.

Test paths	direct	w/ sidetrip
t1 = [1, 2, 3, 5, 2, 6]	i, ii	iii
t2 = [1, 2, 3, 4, 5, 2, 6]	i, iv, vi	/

Note that neither t_1 *nor* t_2 *tours du-path (v), either directly or with a sidetrip. Also note that neither* t_1 *nor* t_2 *tours du-path (iii) directly.* t_1 *does tour du-path (iii) with a sidetrip. But* t_2 *does not tour du-path (iii) with a sidetrip; the problem is the def of* x *in node 4.*

(d)

This question has one possible answer: $\{t_2\}$.

(e)

For all-uses, all six du-paths must be toured. Since the given test set does not have a test path that directly tours either of du-paths (iii) or (v), this question is unsatisfiable. To directly tour the given $du-paths$, *we would two additional test paths. An example all-uses adequate test set (direct touring) is:* $\{t_1, t_2, [1, 2, 6], [1, 2, 3, 4, 5, 2, 3, 5, 2, 6]\}$.

(f)

For this exercise, all-du-paths coverage is the same as all-uses coverage. The reason is that there is only one du-path for each du-pair.