# Math 61 Final

JACOB WAHBEH

TOTAL POINTS

**61 / 67**

QUESTION 1

10 pts

**1.1 5 / 5**

✓ **- 0 pts** Correct

**- 1 pts** Minor error in one part of truth table

**1.2 5 / 5**

✓ **- 0 pts** Correct

**- 1 pts** Minor error in one part of truth table

QUESTION 2

**2 2 / 5**

**- 0 pts** Correct

**- 4 pts** Attempted, but essentially wrong

✓ **- 3 pts** Error in Binomial theorem for (20+1)^{10^100}

**- 2 pts** Error in the terms need to be subtracted

**- 1 pts** Did not explicitly compute or incorrectly computed binomial coefficients / fractions involving factorials

**- 5 pts** No relevant work

QUESTION 3

10 pts

**3.1 5 / 5**

✓ **- 0 pts** Correct

**- 3 pts** construction of x, y are not necessarily non-negative (e.g. when inductively define x' = x-1, y'=y+1)

**- 1 pts** did not verify the x, y obtained are non-negative (using k >= 2)

**- 0.5 pts** incomplete base cases

**3.2 5 / 5**

✓ **+ 5 pts** Correct

**+ 0.5 pts** Use fundamental theorem of arithmetic

**+ 1.5 pts** Apply the fortified condition to conclude exponents >=2

**+ 1.5 pts** Express exponent k_i = 2x_i+3y_i

**+ 1.5 pts** Give correct a, b

QUESTION 4

**4 5 / 5**

✓ **- 0 pts** Correct

**- 1 pts** Swapped variable names in answer

**- 1 pts** Sign error

**- 2.5 pts** Backsubstitution mistake

**- 5 pts** No significant progress

QUESTION 5

**5 5 / 5**

✓ **- 0 pts** Correct

**- 2 pts** -2^n instead of (-2)^n

**- 2.5 pts** Wrong roots

**- 5 pts** No significant progress

QUESTION 6

**6 3 / 5**

**- 0 pts** Correct

**- 2 pts** Missing component which counts injective functions from $$X_1 \to Y_2, X_2\to Y_1$$

✓ **- 2 pts** Used binomial coefficients instead of permutation or things like c!/a! instead of c!/(c-a)!

**- 4 pts** Effort but little to no progress on problem

**- 1 pts** Minor error

**- 5 pts** Blank, no relevant work

QUESTION 7

26 pts

**7.1 2 / 2**

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.2 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.3 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.4 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.5 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.6 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.7 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.8 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.9 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.10 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.11 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

7.12 1 / 2

- 0 pts Correct
- 2 pts Incorrect
✓ - 1 pts Blank

7.13 2 / 2

✓ - 0 pts Correct
- 2 pts Incorrect
- 1 pts Blank

QUESTION 8

8 1 / 1

✓ - 0 pts Correct
- 1 pts Click here to replace this description.

# Math 61 Final

3/20/20
105 114 897
Jacob Wahbeh

1. (1)

| $P$ | $Q$ | $A$: $(P \Leftarrow Q)$ | $B$: $Q \wedge A$ | $B \rightarrow P$ |
|---|---|---|---|---|
| T | T | T | T | T |
| T | F | T | F | T |
| F | T | F | F | T |
| F | F | F | F | T |

yes Tautology

(2)

| $P$ | $Q$ | $A$: $(P \Leftarrow Q)$ | $B$: $Q \Leftarrow P$ | $C$: $P \Leftrightarrow Q$ | $A \wedge B$ | $A \wedge B \rightarrow C$ |
|---|---|---|---|---|---|---|
| T | T | T | T | T | T | T |
| T | F | T | F | F | F | T |
| F | T | F | T | F | F | T |
| F | F | F | F | T | F | T |

yes tautology

2.

$$(a+b)^n = \sum_{k=0}^{n} \binom{n}{k} a^{n-k} b^k \qquad \sum_{k=2}^{10^{100}} 20^k \binom{10^{100}}{k}$$

$$= \sum_{k=2}^{10^{100}} \binom{10^{100}}{k} \left(0^{10^{100}-k}\right) 20^k \quad , \text{missing } k=1,0$$

$$(0+20)^{10^{100}} - \binom{10^{100}}{0} 20^0 - \binom{10^{100}}{1} 20^1$$

$$= \boxed{20^{10^{100}} - 1 - 20(10^{100})}$$

**1.1 5 / 5**

✓ **- 0 pts** Correct

**- 1 pts** Minor error in one part of truth table

# Math 61 Final

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Jacob Wahbeh

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| T | F | T | F | T |
| F | T | F | F | T |
| F | F | F | F | T |

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(2)

| P | Q | A $(P \leftarrow Q)$ | B $Q \leftarrow P$ | C $P \leftrightarrow Q$ | $A \wedge B$ | $A \wedge B \rightarrow C$ |
|---|---|---|---|---|---|---|
| T | T | T | T | T | T | T |
| T | F | T | F | F | F | T |
| F | T | F | T | F | F | T |
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**1.2 5 / 5**

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3/20/20
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| P | Q | A: $(P \Leftarrow Q)$ | B: $Q \wedge A$ | $B \to P$ |
|---|---|---|---|---|
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| T | F | T | F | T |
| F | T | F | F | T |
| F | F | F | F | T |

yes Tautology

(2)

| P | Q | A: $(P \Leftarrow Q)$ | B: $Q \Leftarrow P$ | C: $P \Leftrightarrow Q$ | $A \wedge B$ | $A \wedge B \to C$ |
|---|---|---|---|---|---|---|
| T | T | T | T | T | T | T |
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| F | T | F | T | F | F | T |
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- **- 0 pts** Correct
- **- 4 pts** Attempted, but essentially wrong
- ✓ **- 3 pts Error in Binomial theorem for (20+1)^{10^100}**
- **- 2 pts** Error in the terms need to be subtracted
- **- 1 pts** Did not explicitly compute or incorrectly computed binomial coefficients / fractions involving factorials
- **- 5 pts** No relevant work

3. $\forall k \in \mathbb{N}$ $k \geq 2$ pf $\exists$ $x, y \geq 0 \in \mathbb{N}$ s.t. $k = 2x + 3y$

strong induction

(1) Base cases:

$P(2)$: $2 = 2(1) + 3(0)$ $x = 1$ $y = 0$

$P(3)$: $3 = 2(0) + 3(1)$ $x = 0$ $y = 1$

$P(4)$: $4 = 2(2) + 3(0)$ $x = 2$ $y = 0$

Induction step: Assume for $n \geq 4$ $P(k)$ holds for $k \in (2, 3, \ldots, n)$. WTS $P(n+1)$ is true.

Since $n \geq 4$, $n - 2 \geq 2$ so $P(n-2)$ is true therefore $n - 2 = 2x + 3y$. Now add 3

$2x + 3y + 3 = 2x + 3(y+1) = n - 2 + 3 = n + 1$ ■

$P(n+1)$ is true

(2) For fortified number $n$, must have prime factorization

$n = (p_1 p_1 \ldots)(p_2 p_2 \ldots) \ldots (p_k p_k \ldots)$ $k \in \mathbb{N}$

where $p_i$, $i \in (1, \ldots, k)$ must occur at least 2 times each.

we can rewrite $n$ as follows

$n = \underbrace{(p_1 \ldots p_2 \ldots \ldots p_k)^2}_{a} \underbrace{(p_1 p_2 \ldots p_k)^3}_{b}$

if $p_i$ occurs an odd number of times $> 1$ we can subtract those occurrences and put $p_i$ in $b$. Then for the remaining $l$ occurrences of $p_i$, we can put $p_i^{l/2}$ in $a$ (or if $p_i$ occurred even amount of times)

For example $n = 288 = 2^5 3^2$

for $p_1 = 2$, 3 occurrence go to $b^3$ and rest go to $a^2$

for $p_2 = 3$, 2 occurrences go to $a^2$

$a = 3 \cdot 2$ $b = 2$ $n = (3 \cdot 2)^2 (2)^3$

if there are only even occurrences for all $p_i$ then $b = 1$ ■

**3.1 5 / 5**

✓ **- 0 pts** Correct

**- 3 pts** construction of x, y are not necessarily non-negative (e.g. when inductively define x' = x-1, y'=y+1)

**- 1 pts** did not verify the x, y obtained are non-negative (using k >= 2)

**- 0.5 pts** incomplete base cases

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$2x + 3y + 3 = 2x + 3(y+1) = n - 2 + 3 = n + 1$ ∎

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② For fortified number $n$, must have prime factorization

$n = (p_1 p_1 \ldots)(p_2 p_2 \ldots) \ldots (p_k p_k \ldots)$ $k \in \mathbb{N}$

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$a = 3 \cdot 2$ $b = 2$ $n = (3 \cdot 2)^2 (2)^3$

if there are only even occorrences for all $p_i$ then $b = 1$ ∎

3.2 **5 / 5**

✓ **+ 5 pts** Correct

**+ 0.5 pts** Use fundamental theorem of arithmetic

**+ 1.5 pts** Apply the fortified condition to conclude exponents >=2

**+ 1.5 pts** Express exponent k_i = 2x_i+3y_i

**+ 1.5 pts** Give correct a, b

4. First, find gcd (675, 500) using Euclidean Alg

$675 = 500(1) + 175$
$500 = 175(2) + 150$
$175 = 150(1) + 25$
$150 = 25(6) + 0$

$\gcd(675, 500) = 25$

$25 = 175 - 150 = 175 - (500 - 175(2))$
$= (675-500)(3) - 500 = 675(3) - 500(4)$

now find gcd (72, 25)

$72 = 25(2) + 22$
$25 = 22(1) + 3$
$22 = 3(7) + 1$
$3 = 1(3) + 0$

$\gcd(72, 25) = 1$

plug in

$1 = 22 - 3(7) = 22 - (25-22)(7)$
$= (72-25(2))(8) - (25)(7) = 72(8) - 25(23)$

$1 = 72(8) - (675(3) - 500(4))(23)$

$1 = 72(8) + 675(-69) + 500(92)$

$x = 8, \quad y = -69 \quad z = 92$

**4 5 / 5**

- ✓ **- 0 pts** Correct
- **- 1 pts** Swapped variable names in answer
- **- 1 pts** Sign error
- **- 2.5 pts** Backsubstitution mistake
- **- 5 pts** No significant progress

5. $a_0 = 4$ $a_1 = 10$ $\forall n \geq 1$ $a_{n+1} = 2a_n + 8a_{n-1}$

char poly $p(x)$: $x^2 - 2x - 8 = 0$

$(x-4)(x+2) = 0$ $x = 4, -2$

distinct roots, 2 solutions

ⓐ $(4^n)_{n\geq 0}$ : $1, 4, 16, 64 \ldots$

ⓑ $(-2^n)_{n\geq 0}$ : $1, -2, 4, -8 \ldots$

$b + d = a_0$

$a_n = b(4^n)_{n\geq 0} + d(-2^n)_{n\geq 0}$ $br_1 + dr_2 = a_1$

$b + d = 4$

$b(4) + d(-2) = 10$ $\Rightarrow$

$2b + 2d = 8$

$+ 4b - 2d = 10$

$\Rightarrow 6b = 18$ $b = 3$ $d = 1$

$$a_n = 3(4^n) + (-2^n) \quad n \geq 0$$

$a_0 = 3 + 1 = 4$ ✓

$a_1 = 3(4) - 2 = 10$ ✓

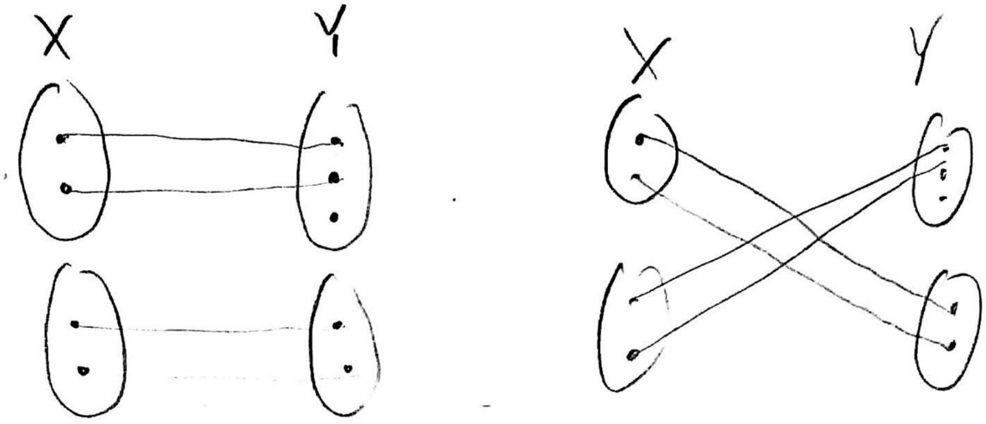
$a_2 = 3(16) + 4 = 52 = 2(10) + 8(4)$ ✓

$a_3 = 3(64) - 8 = 184 = 2(52) + 8(10)$ ✓

**5 5 / 5**

- ✓ **- 0 pts** Correct
- **- 2 pts** -2^n instead of (-2)^n
- **- 2.5 pts** Wrong roots
- **- 5 pts** No significant progress

6.




for a function $g: V \to W$ the # of injective functions is $|W|! / |V|!$ because $V_1$ has $|W|$ elements to choose from, $V_2$ has $|W|-1$, $V_{|V|}$ has $|W|-|V|+1$ choices

for first possibility where $X_1 \to Y_1$ & $X_2 \to Y_2$ we have

$\frac{c!}{a!} \cdot \frac{d!}{b!}$ injective functions

for 2nd possibility where $X_2 \to Y_1$ & $X_1 \to Y_2$ we have

$\frac{d!}{a!} \cdot \frac{c!}{b!}$ injective functions

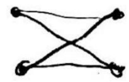
So total is the sum

$$\left(\frac{c!}{a!} \cdot \frac{d!}{b!}\right) + \left(\frac{d!}{a!} \cdot \frac{c!}{b!}\right)$$ total injective functions

**6 3 / 5**

- **- 0 pts** Correct
- **- 2 pts** Missing component which counts injective functions from $$X_1 \to Y_2, X_2\to Y_1$$
- ✓ **- 2 pts Used binomial coefficients instead of permutation or things like c!/a! instead of c!/(c-a)!**
- **- 4 pts** Effort but little to no progress on problem
- **- 1 pts** Minor error
- **- 5 pts** Blank, no relevant work

7.

(1) (F)  even length

(2) (T)

(3) (F) Vacuously true on $X = \emptyset$

(4) (F) $\{1,2,3\}$ $\{2,4,6\}$
$\{1,3\} = 2$

(5) (F) only for odd $K_n$ graph

(6) (F) $x_1, x_2$ can still go to same $y_i$

(7) (T) infinite starting values

(8) (T) n = 1 always

(9) (F)

(10) (F)

(11) (F) $10 \equiv 3 \pmod 7$ $2^{10} \not\equiv 2^3 \pmod 7$

(12)

(13) (F)

8. I liked graph theory because of how it relates to data structures in CS like Binary search trees. Also, I am a visual learner and graphs are very easy for me to visualize.

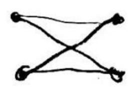
**7.1 2 / 2**

✓ **- 0 pts** Correct

**- 2 pts** Incorrect

**- 1 pts** Blank

7.

(1) (F)  even length

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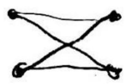
(1) (F)  even length

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- **- 2 pts** Incorrect
- **- 1 pts** Blank

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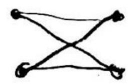
(1) (F)  even length

(2) (T)

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**7.4 2 / 2**

- ✓ **- 0 pts** Correct
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- **- 1 pts** Blank

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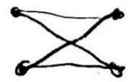
(1) (F)  even length

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7.5 **2 / 2**

- ✓ **- 0 pts** Correct
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- **- 1 pts** Blank

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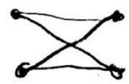
(1) (F)  even length

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(5) (F) only for odd $K_n$ graph

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**7.6 2 / 2**

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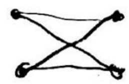
① (F)  even length

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⑦ (T) infinite starting values

⑧ (T) <u>$n = 1$ always</u>

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⑫

⑬ (F)

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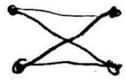
**7.7 2 / 2**

✓ **- 0 pts** Correct

**- 2 pts** Incorrect

**- 1 pts** Blank

7.

1. (F)  even length

2. (T)

3. (F) Vacuously true on $X = \emptyset$

4. (F) $\{1, 2, 3\}$ $\{2, 4, 6\}$

   $\{1, 3\} = 2$

5. (F) only for odd $K_n$ graph

6. (F) $x_1, x_2$ can still go to same $y_i$

7. (T) infinite starting values

8. (T) $n = 1$ always

9. (F)

10. (F)

11. (F) $10 \equiv 3 \pmod 7$ $2^{10} \not\equiv 2^3 \pmod 7$

12.

13. (F)

8. I liked graph theory because of how it relates to data structures in CS like Binary search trees. Also, I am a visual learner and graphs are very easy for me to visualize.

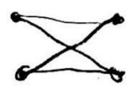
**7.8 2 / 2**

✓ **- 0 pts** Correct

**- 2 pts** Incorrect

**- 1 pts** Blank

7.

(1) (F)  even length

(2) (T)

(3) (F) Vacuously true on $X = \emptyset$

(4) (F) $\{1, 2, 3\}$ $\{2, 4, 6\}$

$\{1, 3\} = 2$

(5) (F) only for odd $K_n$ graph

(6) (F) $x_1, x_2$ can still go to same $y_i$

(7) (T) infinite starting values

(8) (T) <u>n = 1 always</u>

(9) (F)

(10) (F)

(11) (F) $10 \equiv 3 \pmod 7$ $2^{10} \not\equiv 2^3 \pmod 7$

(12)

(13) (F)

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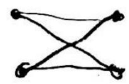
7.9 **2 / 2**

- ✓ **- 0 pts** Correct
- **- 2 pts** Incorrect
- **- 1 pts** Blank

7.

(1) (F)  even length

(2) (T)

(3) (F) Vacuously true on $X = \emptyset$

(4) (F) $\{1, 2, 3\}$ $\{2, 4, 6\}$
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(12)

(13) (F)

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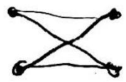
7.10 **2 / 2**

- ✓ **- 0 pts** Correct
- **- 2 pts** Incorrect
- **- 1 pts** Blank

7.

(1) (F)  even length

(2) (T)

(3) (F) vacuously true on $X = \emptyset$

(4) (F) $\{1,2,3\}$ $\{2,4,6\}$
$\{1,3\} = 2$

(5) (F) only for odd $K_n$ graph

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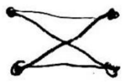
**7.11 2 / 2**

- ✓ **- 0 pts** Correct
- **- 2 pts** Incorrect
- **- 1 pts** Blank

7.
① (F)  even length

② (T)

③ (F) Vacuously true on $X = \emptyset$

④ (F) $\{1, 2, 3\}$ $\{2, 4, 6\}$
$\{1, 3\} = 2$

⑤ (F) only for odd $K_n$ graph

⑥ (F) $x_1, x_2$ can still go to same $y_i$

⑦ (T) infinite starting values

⑧ (T) n = 1 always

⑨ (F)

⑩ (F)

⑪ (F) $10 \equiv 3 \pmod 7$ $2^{10} \not\equiv 2^3 \pmod 7$

⑫

⑬ (F)

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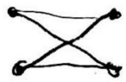
**7.12 1 / 2**

- **- 0 pts** Correct
- **- 2 pts** Incorrect
- ✓ **- 1 pts** Blank

7.

1. (F)  even length

2. (T)

3. (F) Vacuously true on $X = \emptyset$

4. (F) $\{1, 2, 3\}$ $\{2, 4, 6\}$
$\{1, 3\} = 2$

5. (F) only for odd $K_n$ graph

6. (F) $x_1, x_2$ can still go to same $y_i$

7. (T) infinite starting values

8. (T) <u>$n = 1$ always</u>

9. (F)

10. (F)

11. (F) $10 \equiv 3 \pmod 7$ $2^{10} \not\equiv 2^3 \pmod 7$

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13. (F)

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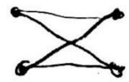
**7.13 2 / 2**

- ✓ **- 0 pts** Correct
- **- 2 pts** Incorrect
- **- 1 pts** Blank

7.

(1) (F)  even length

(2) (T)

(3) (F) Vacuously true on $X = \emptyset$

(4) (F) $\{1,2,3\}$ $\{2,4,6\}$
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(5) (F) only for odd $K_n$ graph

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(12)

(13) (F)

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**8 1 / 1**

✓ **- 0 pts** Correct

**- 1 pts** Click here to replace this description.