

### SEMESTER A FINAL ASSESSMENT

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- You must not seek or obtain help from anyone else.

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I have read and agree to the above statement.

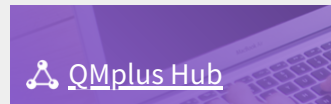
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MTH4113 / MTH4213 - NUMBERS, SETS AND FUNCTIONS - 2021/22

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**QUESTION 1**

Not yet answered Marked out of 12

Suppose  $P, Q$  and  $R$  are statements. Complete the truth table for the statement  $(P \text{ or } Q) \Rightarrow (P \text{ and } (\text{not } R))$ .

$P$	$Q$	$R$	$(P \text{ or } Q) \Rightarrow (P \text{ and } (\text{not } R))$
true	true	true	<input type="text"/>
true	true	false	<input type="text"/>
true	false	true	<input type="text"/>
true	false	false	<input type="text"/>
false	true	true	<input type="text"/>
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false	false	true	<input type="text"/>
false	false	false	<input type="text"/>

**QUESTION 2**

Not yet answered Marked out of 10

Suppose  $A, B$  and  $C$  are finite sets of real numbers.

Decide whether each of the following is a set, a number, a statement or meaningless.

$|A| + |C|$

$A \cup (B \cap C)$

$B = \{n \in \mathbb{N} : n + 1 \in A\}$

$A \cap B$  is disjoint

$((A \cup B) \cup C) \cup A$

**QUESTION 3**

Not yet answered Marked out of 10

True or false?

25 is a factor of 5.

$4 \mid 0$ .

If  $a, b, c \in \mathbb{Z}$  and  $a \mid b$  and  $b \mid c$ , then  $c \mid a$ .

If  $a \in \mathbb{Z}$  and  $6 \nmid a$ , then  $3 \nmid a$ .

If  $a, b \in \mathbb{N}$ , then  $\text{lcm}(a^2, b^2) = \text{lcm}(a, b)^2$ .

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**QUESTION 4**

Not yet answered Marked out of 15

Let  $A$  and  $B$  be finite sets satisfying  $|A| = 6$ ,  $|B| = 7$  and  $|A \cap B| = 2$ .

Calculate the following:

$$\binom{|A|}{3} = \text{[input]}$$

$$|A \cup B| = \text{[input]}$$

The number of non-empty subsets of  $B$  is [input]

$$|\{S : S \subseteq A, |S| = 3 \text{ and } S \cap B = \emptyset\}| = \text{[input]}$$

$$\max \{ |S| : S \subseteq A \cup B, |S \cap A| \text{ is even and } |S \cap B| \text{ is even} \} = \text{[input]}$$

**QUESTION 5**

Not yet answered Marked out of 15

Decide whether each of the following functions is injective and/or surjective.

$f : \mathbb{N} \rightarrow \mathbb{N}$  defined by  $f(n) = 2n$ .

- $f$  is injective but not surjective
- $f$  is surjective but not injective
- $f$  is both injective and surjective
- $f$  is neither injective nor surjective.

$g : \mathbb{R} \times \mathbb{R} \rightarrow \mathbb{R} \times \mathbb{R}$  defined by  $f(m, n) = (m^2, m + n)$ .

- $g$  is injective but not surjective
- $g$  is surjective but not injective
- $g$  is both injective and surjective
- $g$  is neither injective nor surjective.

$h : \mathbb{N} \rightarrow \mathbb{N}$  defined by

$h(n) =$  the number of digits of  $n^2$ .

- $h$  is injective but not surjective
- $h$  is surjective but not injective
- $h$  is both injective and surjective
- $h$  is neither injective nor surjective.

## QUESTION 6

Not yet answered Marked out of 15

Find the supremum of each of the following sets. (If the supremum is infinite, enter the word "infinity". If it is a real number, round it to 1 decimal place.)

$\{4, 1, 2, 3\}$

$\{(x-1)^2 : x \in \mathbb{R}, 0 \leq x < 2\}$

$\left\{\frac{n^2}{4} : n \in \mathbb{Z}\right\}$

$\left\{\frac{n+1}{n} : n \in \mathbb{N}\right\}$

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**QUESTION 7**

Not yet answered Marked out of 8

Use Euclid's algorithm to find the greatest common divisor of 52 and 80. Hence find the lowest common multiple of 52 and 80.

Upload a PDF of your solution. Show your working clearly as well as giving the answer.

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**QUESTION 8**

Not yet answered Marked out of 10

Give a proof by induction of the following statement.

If  $n$  is a positive integer, then

$$\sum_{a=1}^n (3a + 2) = \frac{n(3n + 7)}{2}.$$

(Upload your written proof in PDF format.)

Maximum file size: Unlimited, maximum number of files: 1

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QUESTION 9

Not yet answered Marked out of 5

Here's an incorrect theorem with an incorrect proof.

**Theorem:** There is no rational number  $x$  such that  $1 < x < 2$ .

**Proof:** We use proof by contradiction. So suppose there are rational numbers between 1 and 2, and let  $x$  be the smallest one. Because  $x$  is rational, we can write  $x = \frac{a}{b}$  where  $a$  and  $b$  are integers. Now let  $y = \frac{x+1}{2}$ . Then  $y = \frac{a+b}{2b}$ , so  $y$  is rational.

The assumption that  $x > 1$  gives  $x + 1 > 2$ , which implies that  $y > 1$ . The assumption that  $x > 1$  also gives  $2x > x + 1$ , which implies that  $y < x$ .

But now  $y$  is a rational number between 1 and 2 which is smaller than  $x$ . This contradicts the assumption that  $x$  was the smallest one. So the theorem is true using proof by contradiction.  $\square$

Explain in a few sentences what's wrong with the proof. (You can either type your answer in the box or upload a scan of your written answer as a PDF.)

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