

**Name:**

Each of the multiple choice questions below has one correct choice. Circle the correct choice.

**Q1**

An SIR model for a system is created and described by the following equations.

$$S' = \alpha S - \beta S - \gamma SI$$

$$I' = \gamma SI - \beta I - \delta I$$

$$R' = \delta I - \beta R - \rho R$$

A mask program is introduced which significantly reduces the probability of infection per encounter. Which of the coefficients above is likely to decrease?

- (a)  $\beta$
- (b)  $\gamma$
- (c)  $\delta$
- (d)  $\rho$

**Q2**

A 3-dimensional vector field is described by the following equations.

$$X' = X - Y$$

$$Y' = Y - Z$$

$$Z' = Z - X$$

(For example, the change vector at the point  $(10, 1, 0)$  is  $(9, 1, -10)$ ). Which of the following statements regarding the vector field above is false?

- (a) The change vector at the point  $(0, 1, 0)$  has the same length as the change vector at the point  $(2, 1, 1)$ .
- (b) The change vector at the point  $(1, 0, 0)$  and the change vector at the point  $(-1, 0, 0)$  have opposite directions.
- (c) The change vector at the point  $(1, 1, 1)$  is a zero vector.
- (d) The change vector at the point  $(0, 1, 0)$  is a unit vector.

**Q3**

The population of a feral buffalo herd in Australia<sup>1</sup> is found to be described by

$$P' = P^2 - 4P.$$

At time  $t = 4$  the population is 5. Euler's method is used to estimate the population at time  $t = 6$  using the interval  $\Delta t = 1$ . This estimate is:

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<sup>1</sup>Yes, they were a serious problem in Australia in the 20th century.

- (a) 60
- (b) 70
- (c) 80
- (d) 90

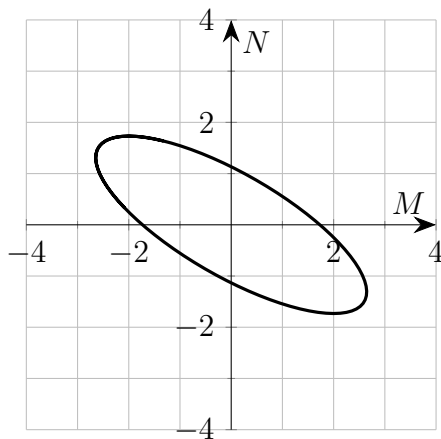
**Q4**

A line in the  $xy$ -plane with slope 5 passes through the points  $(3, 2)$  and  $(1, m)$ . The value of  $m$  is:

- (a)  $-8$
- (b)  $-4$
- (c)  $4$
- (d)  $8$

**Q5**

The state space trajectory of a system with variables  $M$ ,  $N$  is shown below. Assuming that as time increases *the trajectory goes in a counterclockwise direction*, which of the following graphs is a possible time-series of the trajectory? (Note: in the time-series graphs, the horizontal axis represents time.)



- (a)
- (b)
- (c)
- (d)