Grade 11 Computing

Unit 5 · Modeling and Simulation

WORKSHEET

Full marks 31

Name _____ Class _____ Roll no. ____ Date _____ Marks _____ / 31

1 Key words [4]

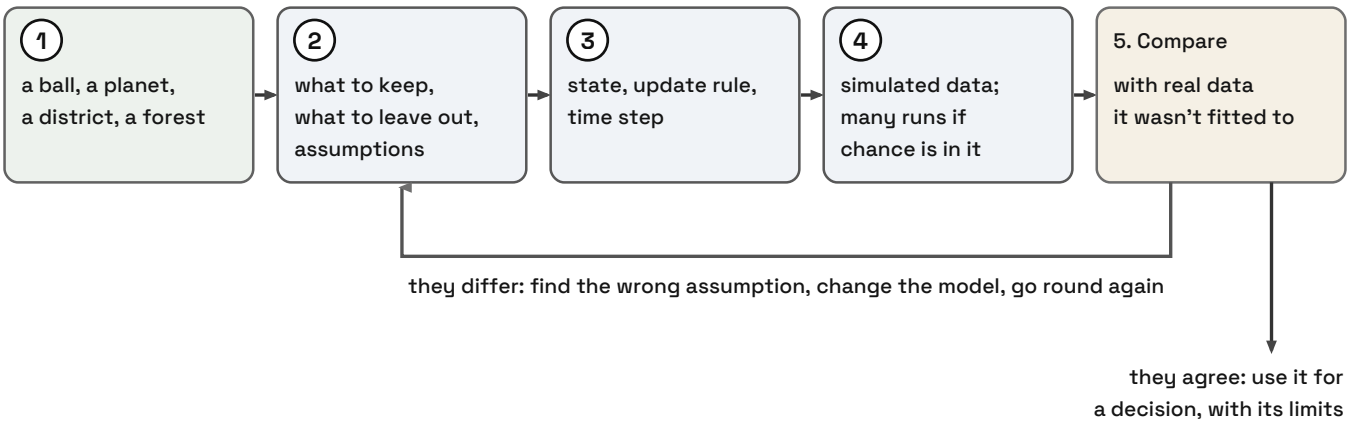
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

assumption	**compiler**	**heap**	**model**	**Monte Carlo**	**parameter**	**state**	**stochastic**
time step	**update rule**						

A _____ keeps only what matters about a real system. What it takes to be true without checking is an _____, and a number that can be changed to try another case, such as R_0, is a _____. Everything a simulation needs to know about the system at one moment is its _____, and the _____ turns it into the state one _____ later. A model that uses random numbers, so that each run is different, is _____. Running such a model many times and counting the results is the _____ method.

2 Label the diagram [2]

The diagram shows the cycle of building a model. Write the word or words that belong in place of 1 to 4. Each carries 0.5 mark.



1. _____ 2. _____

3. _____ 4. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. A model of a bus route from Bhaktapur to Ratnapark keeps the stops, the distances and the usual time between stops. Which is an **assumption** of this model? [1]

a. the distance between two stops

b. the traffic on a Tuesday morning is like the traffic on any other morning

c. the bus's route

d. the number of stops

ii. A simulation with a time step of 0.1 s is off by 3.4 m. With Euler's method, about how far off will it be with a step of 0.01 s? [1]

a. 34 m **b.** 3.4 m

c. about 0.34 m **d.** exactly 0 m

iii. A disease has $R_0 = 4$. What share of people must be immune for herd immunity? [1]

a. 25% **b.** 40%

c. 75% **d.** 100%

iv. A Monte Carlo estimate with 1,000 trials typically varies by about ±2%. About how many trials would bring that to ±0.2%? [1]

a. 2,000 **b.** 10,000

c. 100,000 **d.** 1,000,000,000

v. Which of these is a **stochastic** model? [1]

a. the thrown ball with air resistance

b. the Euler–Cromer orbit

c. the hostel outbreak, where each day's meetings and recoveries are decided by random numbers

d. the SIR model of Bhaktapur

4 An epidemic, one day [3]

Answer in the box.

A school of 1,000 people has 990 susceptible, 10 infected and 0 recovered. The disease has $R_0 = 2$ and lasts 5 days, so each infected person passes it on to `spread` $= R_0 \div$ days sick people a day, if all can catch it. New cases in a day = spread × S × I ÷ people; recoveries = I ÷ days sick.

i. Work out `spread`, and S, I and R after one day.

ii. What share of the school must be vaccinated for herd immunity?

Answer: _____

5 Trace a simulation [4]

A stone is thrown straight up at 15 m/s. The program moves it by Euler's method, taking g as 10 m/s^2. Fill in the table, then answer.

```
g = 10
dt = 0.5
y, vy = 0.0, 15.0
t = 0.0
while y >= 0:
    print(t, y, vy)
    y = y + vy * dt
    vy = vy - g * dt
    t = t + dt
print("Below the ground at", t)
```

i. Fill in a row for each line the loop prints, then the last line printed.

t	y	vy	Output
0.0	0.0	15.0	0.0 0.0 15.0

ii. By the formulas of physics, the stone goes 11.25 m high and lands after 3 s. Why does the simulation give a different answer, and how could it be made closer?

6 Short answer [2]

Write a short answer to the following question.

A model of Nepal's population was fitted to the censuses of 1971 to 2001 and matches them closely, but for 2021 it gives about 26% more people than the census counted. Why doesn't the close match from 1971 to 2001 show that the model is good, and what should be done next?

7 What does it print? [2]

Write exactly what the program prints, in the box under it.

A room heater with a thermostat, one minute at a time:

```
temp = 17.0
heater = False
for minute in range(1, 5):
    if temp < 18:
        heater = True
    elif temp > 20:
        heater = False
    if heater:
        temp = temp + 1.5
    else:
        temp = temp - 0.5
    print(minute, temp, heater)
```

OUTPUT

8 Find and fix the bug [3]

Read the program, then answer.

This Monte Carlo program should estimate the chance that two dice add up to 7, but it prints `0.0` every time it is run.

```
import random

hits = 0
trials = 10000
for i in range(trials):
    random.seed(7)
    a = random.randint(1, 6)
    b = random.randint(1, 6)
    if a + b == 7:
        hits = hits + 1
print(hits / trials)
```

i. Why does it print 0.0?
ii. How should it be fixed?
iii. About what will the fixed program print, and why?

9 Write a program [4]

Write the program in Python on the lines. Any program that gives the right result gets the marks.

Write a Monte Carlo program that estimates the chance that, in 5 tosses of a coin, at least 4 come up heads. Use 100,000 trials. (`random.random()` gives a number from 0 up to 1; below 0.5 can count as heads.)

10 Think [2]

Think, then answer.

A hospital uses the SIR model to decide how many beds to get ready for an epidemic. Name two assumptions of the model that may make its peak wrong, and say for each whether the real peak would then be higher or lower.

11 Activity: How big a step? (not marked)

At a computer, open the unit's page (the QR code) and find **How big a step?** Try each time step, and fill in the table.

Time step	Steps	Lands (Euler)	Off by
0.5 s			
0.2 s			
0.1 s			
0.01 s			