LAB 4

Functions

Learning Goals:
Write and call Python user-defined functions.
Implement user input and formatted output.
Practice with plotting.

4.1 Compound Interest

The following Python code attempts to calculate the balance of a savings account with an annual interest rate of 5% after 4 years, assuming that the account starts with a balance of $100:

```
>>> balance = 100
>>> def add_interest(balance, rate):
...     balance += balance * rate / 100
...
>>> for year in range(4):
...     add_interest(balance, 5)
...     print('Balance after year {}: ${:.2f}'.format(year+1, balance))
...
Balance after year 1: $100.00
Balance after year 2: $100.00
Balance after year 3: $100.00
Balance after year 4: $100.00
```

a) First, explain why this code does not work. (2 points)

b) Fix the above code or provide an alternative Python code that does work as intended. Be sure to include your new code and its output with your lab submission. (2points)

4.2 Range and Height of a Projectile

The range of a projectile launched at an angle α and speed v on a flat surface is given by

$R = \frac{v^2 \sin(2\alpha)}{g}$, where g = 9.81 m s^{-2} is the acceleration due to Earth's gravity.

The maximum height that the projectile achieves is given by $H = \frac{v^2 \sin^2(\alpha)}{2g}$ (neglecting air resistance and the curvature and rotation of the Earth).

Write a function in Python to calculate and return the range R and maximum height H of a projectile, taking α and v as arguments. Test your code using the values $\alpha = 30°$ and v = 10 m s^{-1}.
(10 points)

4.3 Position, Velocity, and Acceleration of a Particle

The position x as a function of time of a particle that moves in one dimension is given by

$$x(t) = -0.2t^3 + 0.5t^2 + 4t - 22,$$

where x has units of meters and t units of seconds. The velocity $v(t)$ of the particle is determined by the derivative of $x(t)$ with respect to t, and the acceleration $a(t)$ is determined by the derivative of $v(t)$ with respect to t (i.e., $v(t) = d\,x(t)/dt$ and $a(t) = d\,v(t)/dt$).

a) First, derive the analytic expressions for the velocity and acceleration of the particle, and define Python functions for these, as well as for the position x (three functions in total).

b) Next, add code that prompts the user to input a value of t, and then calculates and displays the corresponding values of x, v, and a for this input value of t. Use the functions you defined in part a), and properly formatted output.

c) Finally, use your Python functions to make plots of the position, velocity, and acceleration as a function of time for the time interval $0 \leq t \leq 8$. Use plot titles and label the axes appropriately with the correct units. *Hint: enclose mathematical expressions in $ symbols to get nicer formatting. For example:* `xlabel('$x$ [m]')`.
(16 points)