Part A

Question 1 –

```
function partAQ1(xPosition,Elevation)

plot(xPosition,Elevation)
title('Graph of Position and Elevation')
xlabel('Position')
ylabel('Elevation')

end
```

Question 2 –

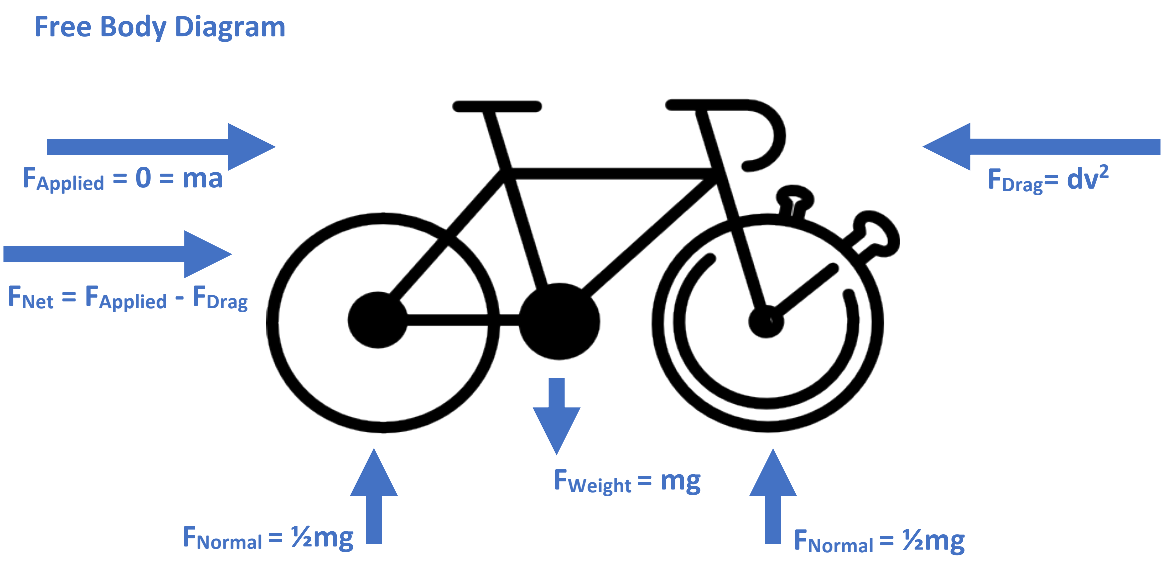
```
function Distance = partAQ2(xPosition,Elevation)
% This section finds the diff for xPosition
N = 1;
for i = 1:length(xPosition)
    a = xPosition(N:N+1);
    difference_a(i) = (((a(:,end))-(a(:,1))));
end

% This section finds the diff for Elevation
N2 = 1;
for ii = 1:length(Elevation)
    b = Elevation(N2:N2+1);
    difference_b(ii) = (((b(:,end))-(b(:,1))));
    N2 = N2 + 1;
    if N2 == length(Elevation)
        N2 = length(Elevation) - 1;
    end
end

% This section sums the hypot of the diffs
Final = hypot(difference_a(1:end-1),difference_b(1:end-1));
sum_final = 0;
for i = 1:length(Final)
    sum_final = sum_final + Final(i);
end
% Final Distance
Distance = sum_final
end
```

Question 3 –

```
function ElevationGain = partAQ3(Elevation)


% This section finds the diff fo elevation

N2 = 1;
for ii = 1:length(Elevation)
    b = Elevation(N2:N2+1);
    difference_b(ii) = (((b(:,end))-(b(:,1))));
    N2 = N2 + 1;
    if N2 == length(Elevation)
        N2 = length(Elevation) - 1;
    end
end
% This section sums the diff

Final = difference_b(1:end-1)
Final2 = (Final(Final>0))
sum_final = 0;
for i = 1:length(Final2)
    sum_final = sum_final + Final2(i);
end

% Final Elevation Gain

ElevationGain = sum_final


end
```

Part B

Question 1 –



Since the bike is coasting, there is no external force from the rider pushing it forward. Therefore, $F_{Applied}$ will equal 0.

Creating ODE

$ma = -dv^2$

Let a = dv/dt – (Write in terms of velocity)

$m*(dv/dt) = -dv^2$
$dv/dt = -(d/m) * v^2$

Final ODE

$$\frac{dv}{dt} + \frac{d}{m}v^2 = 0$$

Question 2 –

ODE In Standard Form → $$\frac{dv}{dt} + \frac{d}{m}v^2 = 0$$

Generic Linear ODE → $$\frac{dx}{dt} + p(t)x = Q(t)$$

Linearize v^2 about v = 10m/s

f(x) ≈ f(a) + f'(a) (x-a)
$v^2 \approx v^2 + 2v\ (x-10)$
$v^2 \approx v^2 + 2vx - 20v)$
$v^2 \approx 100 + 20x - 200$
$v^2 \approx 20x - 100$ ------------------ > Let $x = v_a$
$v^2 \approx 20v_a - 100$

$$\frac{dv_a}{dt} + \frac{d}{m}(20v_a - 100) = 0$$

$$\frac{dv_a}{dt} + \frac{20d}{m}v_a - \frac{100d}{m} = 0$$

Final Linearized Equation $$\frac{dv_a}{dt} + \frac{20d}{m}v_a = \frac{100d}{m}$$

Question 3 –

$$\frac{dV_a}{dt} + \frac{20d}{m} V_a = \frac{100d}{m}$$

Solve

$m = 70kg$, $d = 1$

→ general $\frac{dy}{dx} + P(t)y = Q(t)$

↳ where

$$P(t)_y = \frac{20d}{m} = \frac{20}{70} = \frac{2}{7}$$

$$Q(t) = \frac{100d}{m} = \frac{100}{70} = \frac{10}{7}$$

$$R(t) = e^{\int P(t)\,dt}$$

$$R(t) = e^{\int \frac{2}{7}\,dt}$$

$$R(t) = e^{\frac{2t}{7}}$$

$$V_a(t) = \frac{1}{R(t)} \int R(t)\,Q(t)\,dt$$

$$V_a(t) = \frac{1}{e^{\frac{2t}{7}}} \int e^{\frac{2t}{7}} \frac{10}{7}\,dt$$

$$V_a(t) = \frac{1}{e^{\frac{2t}{7}}} \times \left(5e^{\frac{2t}{7}} + C_1\right)$$

$$V_a(t) = 5 + C_1 e^{-\frac{2}{7}t}$$

→ initial conditions

$V_a(0) = 10$

$10 = 5 + C_1 \cancel{e^{-\frac{2}{7} \times 0}}$

$\frac{10}{5} = C_1$

$C_1 = 5$

$\therefore V_a(t) = 5 + 5e^{-\frac{2}{7}t}$ m/s

Final Equation = $V_a(t) = 5 + 5e^{(-2/7)t}$ m/s

Question 4 –

$$\frac{dv}{dt} + \frac{d}{m} v^2 = 0 \qquad d = 1 \quad m = 70$$

$$\frac{dv}{dt} + \frac{1}{70} v^2 = 0$$

$$\frac{dv}{dt} = -\frac{1}{70} v^2$$

$$\int \frac{1}{-\frac{1}{70} v^2} \, dv = \int dt$$

$$\frac{70}{v} = t + c_1$$

$$v = \frac{70}{t + c_1}$$

<u>initial conditions</u>

$$V(0) = 10$$

$$10 = \frac{70}{t + c_1} = \frac{70}{0 + c_1}$$

$$10 = \frac{70}{c_1}$$

$$c_1 = \frac{70}{10} = 7$$

$$\therefore \; V = \frac{70}{7 + t}$$

Final Equation = V = 70 / (7+t) m/s

Question 5 –

```
function graph()
clc

% Linear Graph
ylim([0 10])
x = [0:60];
y = 5 + 5*exp((-2/7)*x);
plot(x,y)

% Non - Linear Graph
hold on
y = (70./(x+7));
plot(x,y)

title('Velocity Time Graph')
xlabel('Time (seconds)')
ylabel('Velocity (m/s)')
legend('Linearised ODE','Original ODE')
end

% The graph looks accurate till around t = 2 - 2.6 seconds, then after
this time this model cannot be used. As it becomes too inaccurate due
to the graphs separating.
```