Module 1 – Motion – Instructions

INTRODUCTION

1 Here are some special equations from the textbook. In these equations, d stands for the distance from a starting point, v stands for the velocity at any moment in time, and a stands for a constant (nonchanging) acceleration (Ostdiek and Bord 2018, 39).

    a Distance from a starting point when the velocity is constant:

$$d = vt \tag{1}$$

    b Distance for an object starting from rest with acceleration constant:

$$d = \frac{1}{2}at^2 \tag{2}$$

    c Velocity when an object starts from rest and acceleration is constant:

$$v = at \tag{3}$$

    d For freely falling bodies (used in Part III[1]):

$$a = g \tag{4}$$

2 **NOTE:** *In this simulation, the letter x is used to represent the distance from a starting point, instead of d as in your book.*

3 Data tables are found in the worksheet. When recording your data in the worksheet and making calculations for Parts I[2] and II[3], *record values to three decimal places*. After you have completed the worksheet, you will need to submit your results in WebAssign.

LEARNING OUTCOMES (FROM SYLLABUS)

- Define and analyze concepts such as the following: velocity, acceleration, force, inertia, mass, work, energy (kinetic, potential, etc.), momentum (linear and angular), gravity, tides, power, pressure, density, temperature, thermal expansion, heat, specific heat capacity, waves, sound, electric charge, current, magnetism, electromagnetic waves (including light), photons, and radioactivity.

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[1]manual.html#part3
[2]manual.html#part1
[3]manual.html#part2

- Discuss the various types of motion: Newton's Laws (including his Universal Law of Gravitation); the conservation laws of physics; the laws of electricity (e.g., Coulomb's and Ohm's Laws) and magnetism; the properties of waves (viz., sound and electromagnetic, including light); and the basic principles of atomic and nuclear physics, relativity, and quantum theory.

- Solve a variety of basic problems in particle kinematics (uniform motion and accelerated motion, including "free fall"), dynamics using Newton's Laws of Motion and the conservation laws of energy and momentum (e.g., collisions), fluid mechanics (including Archimedes' and Bernoulli's Principles), thermodynamics, wave motion, basic electricity (Coulomb's and Ohm's Laws), and radioactive decay.

- Interpret the results of simple experiments and demonstrations of physical principles.

EXPERIMENT SIMULATION

Use this Experiment Simulation[4] to conduct the experiment according to the instructions in Parts I[5], II[6], and III[7] below. Follow the instructions *explicitly*.

WORKSHEET

Please print the worksheet for this experiment. You will need this sheet to record your data.

PART I: MOTION WITH CONSTANT VELOCITY

Application/Example: Travel between two points at constant velocity, on the road or in the air.

NOTE:

In order to set the barriers to the specified values below, you will need to increase the simulation display resolution by zooming into the simulation window. Use "Ctrl +" or "Command +" (as required by your operating system) approximately five times to zoom in—this should provide the appropriate degree of display resolution to set the barriers to the required values. You may zoom out ("Ctrl –" or "Command –") the appropriate number of times to run the simulation. These increases/decreases of display resolution do not affect the results of the simulation, only your ability to properly set the light barriers values (zoom in) and to see the results of the simulation (zoom out).

Step 1: **Set-up**

a Drag the green barrier to 20.000 m and the red barrier to 40.000 m.

b Set initial position of 0.00 m.

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[4]http://www.walter-fendt.de/html5/phen/acceleration_en.htm
[5]manual.html#part1
[6]manual.html#part2
[7]manual.html#part3

c   Set initial velocity of 5.00 m/s.

d   Set acceleration of 0.00 m/s^2.

e   The **Show Velocity Vector** radio button is **on** (shows a black dot in the radio button). The **Show acceleration vector** automatically switches off (no black dot in the radio button).

f   Uncheck the **Slow motion** box (unless you need it).

Step 2

Run the simulation for initial conditions ($x = 0.00$ m; $v = 5.00$ m/s; $a = 0.00$ m/s^2) and obtain your data.

a   Click the **Start** button.

b   Click **Pause** to stop the car after it passes the red light barrier.

c   From the colored time boxes (NOTE: the green box is for the green light barrier at $x = 20.000$ m and the red box is for the red light barrier at 40.000 m), record the time for each position value in Table 1 on the worksheet. Remember, *record values to three decimal places.*

d   Move the red light barrier to 50.000 m (this resets the simulation) and click the **Start** button to run the simulation. Stop the car after it passes the red light barrier and record the time (from the red box) it took to reach the red light barrier (at 50.000 m).

e   Calculate the distance traveled for each entry and compare it to the graph.

f   Remember, $V_{\text{average}} = V_{\text{initial}} = V = 5.00$ m/s (i.e., the velocity is constant). Calculate the expected position for each time.

g   For all the runs, observe and describe the graphs of position (x), velocity (v), and acceleration (a). (See the box for a list of acceptable descriptions.)

h   Answer the first two questions for Part I[8] on the worksheet.

Use the following as acceptable descriptions.

Horizontal line	Decreasing straight line
Vertical line	Increasing parabolic curve
Increasing straight line	Decreasing parabolic curve

Step 3

Rerun the simulation (as described in Step 2 above) with initial conditions ($x = 0.00$ m; $v = 10.00$ m/s; $a = 0.00$ m/s^2) and obtain your data.

a   Fill in Table 1 for this simulation.

b   Answer the next two questions for Part I[9] on the worksheet.

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[8]manual.html#part1
[9]manual.html#part1

When recording your data in the worksheet and making calculations, **_record values to three_** **_decimal places_**. After you have completed the worksheet, you will need to submit your results in WebAssign.

PART II: MOTION WITH CONSTANT POSITIVE ACCELER-ATION

Application/Example: Aircraft launched from carrier.

Step 1: Set-up

a   Drag the green barrier to 20.000 m and the red barrier to 40.000 m.

b   Set initial position of 0.00 m.

c   Set initial velocity of 0.00 m/s.

d   Set acceleration of 1.00 m/s^2.

e   Click the radio button for **Show acceleration vector** (shows a black dot in the radio button). The **Show velocity vector** automatically switches off (no black dot in the radio button).

f   Uncheck the **Slow motion** box (unless you need it).

Step 2

Run the simulation with initial conditions ($x = 0.00$ m; $v = 0.00$ m/s; $a = 1.00$ m/s^2) and obtain your data.

a   Click the **Start** button.

b   Click **Pause** to stop the car after it passes the red light barrier.

c   From the colored time boxes (NOTE: the green box is for the green light barrier at $x = 20.000$ m and the red box is for the red light barrier at 40.000 m), record the time for each position value in Table 2 on the worksheet. Remember, **_record values to three decimal places_**.

d   Move the red light barrier to 50.000 m (this resets the simulation) and click the **Start** button to run the simulation. Stop the car after it passes the red light barrier and record the time (from the red box) it took to reach the red light barrier (at 50.000 m).

e   Calculate the distance traveled for each entry and compare it to the graph.

      i   Determine the Calculated Position by using equation 2 above.

      ii   Determine the Calculated Velocity by using equation 3 above.

f   For all the runs, observe and describe the graphs of position (x), velocity (v), and acceleration (a). Use the column labeled **Describe**.

> *Use the following as acceptable descriptions.*
>
> Horizontal line   Decreasing straight line
> Vertical line   Increasing parabolic curve
> Increasing straight line   Decreasing parabolic curve

Step 3

Rerun the simulation (as described in Step 2 above) with initial conditions ($x = 0.00$ m; $v = 0.00$ m/s; $a = 2.00$ m/s^2) and obtain your data.

a Click **Reset** to rerun the simulation.

b Fill in Table 2 for this simulation.

Step 4: **Vector Observations**

a Click **Reset**, click the radio button for **Show velocity vector** (shows a black dot in the radio button). The **Show acceleration vector** automatically switches off (no black dot in the radio button).

b Repeat all of the above for Part II[10] without recording any measurements, but this time run the simulations and observe what happens to the ***Velocity vector during the runs.***

c Then repeat with the acceleration vector enabled. Click the radio button for **Show acceleration vector** (shows a black dot in the radio button). The **Show velocity vector** automatically switches off (no black dot in the radio button).

d Answer the following questions in the spaces provided below Table 2.

> **i**   What happens to the velocity vector during the run?
> **ii** What happens to the acceleration vector during the run?

Step 5

Answer the questions for Part II on the worksheet.

When recording your data in the worksheet and making calculations, ***record values to three decimal places***. After you have completed the worksheet, you will need to submit your results in WebAssign.

PART III: MOTION – INITIAL POSITIVE VELOCITY WITH CONSTANT NEGATIVE ACCELERATION

Application/Example: Aircraft landing on a carrier; ball thrown up into the air.

Step 1: **Set-up**

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[10]manual.html#part2

a Drag the green barrier to 25 m.

b Set initial position of 0.00 m.

c Set initial velocity of 10.00 m/s.

d Set acceleration of –2.00 m/s^2. ***Note negative acceleration.***

e Click the radio button for **Show velocity vector** (shows a black dot in the radio button). The **Show acceleration vector** automatically switches off (no black dot in the radio button).

f Uncheck the **Slow motion** box (unless you need it).

Step 2

Run Simulation and obtain your data.

a Click the **Start** button.

b Click **Pause** to stop the car after it passes the 0-meter mark on the return trip.

c Using **only** the **position (x) graph**, determine the **farthest distance** from the origin (***the distance at the peak of the parabola, not the total distance traveled***). Record your answers in Table 3, **Distance**.

d Using **only** the **position (x) graph**, determine the **time** that the car reaches the **farthest distance** from the origin. Record your answers in Table 3, **Time**.

e Now use **only** the **velocity (v) graph** to determine the **velocity** at the **time** found in Step 2d above. Record your answers in Table 3, **Velocity**.

f Now use **only** the **acceleration (a) graph** to determine the **acceleration** at the **time** found in Step 2d above. Record your answers in Table 3, **Acceleration**.

g Click **Reset** and run the simulation again, but this time only observe the velocity vector on the car.

h Click **Reset**, select the Show acceleration vector radio button, and run the simulation again, but this time only observe the acceleration vector on the car.

Step 3

Answer the questions for Part III on the worksheet.

Use the following as acceptable descriptions.

Horizontal line	Decreasing straight line
Vertical line	Increasing parabolic curve
Increasing straight line	Decreasing parabolic curve