Unity Student Worksheet

| Lesson 1: Force

Parameter check:

What parameters did you use in Lesson 1?: **Mass: 10 kN, Spring force: 5000 N**

The formula to calculate **force** is: ***F=ma***

The formula that calculates **velocity** is: ***V=d/t***

The formula that calculates **acceleration** is: $a=\Delta V/\Delta t$

There are a set of parameters that don't allow the ball to launch:

What are they? **If spring force is less than or equal to the weight of the ball**

Why don't they work? **The resultant force will either be 0 or negative and therefore there will be no acceleration in forward direction.**

Find the acceleration in the launch direction of your ball right after it was released, use the parameters you entered in the forces lesson. Write out the variables that you know first, then document your calculations.

$$F = ma$$

$$a = \frac{F}{m}$$

$$a = \frac{1475\ [N]}{10\ [kg]}$$

$$a = \frac{1475\ \left[\cancel{kg}/_{m/s^2}\right]}{10\ [\cancel{kg}]}$$

$$a = 147.5\ m/s^2$$

Knowns:

F = 1475 N

M = 10 kg

Note: $1\ N = 1\ {}^{kg}/_{m/s^2}$

Calculate the average velocity of the ball in the horizontal axis using the distance and time displayed in the unity editor.

Knowns:

d = 32.85 m

t = 2.57 s

V_x = ?

$$V = {}^{d}/_{t}$$

$$V_x = {}^{32.85\text{m}}/_{2.57s}$$

$$V_x = 12.78\ m/s$$

Will the velocity profile in the x-axis change at different points along the trajectory of the projectile? Why or why not? **No because there are no forces applied to the ball in the horizontal and therefore no acceleration, so the velocity will remain constant.**

Lesson 2: Energy

Parameter check:

What parameters did you use in Lesson 2? **Mass: 2 kN, Spring force: 2500 N**

What are the four kinematic equations?

1. $V = V_i + at$ 2. $d = \left(\frac{V_i + V_f}{2}\right) \times t$

3. $d = \frac{1}{2}at^2 + V_i t + d_i$ 4. $V_f^2 = V_i^2 + 2ad$

Explain how the law of conservation of energy applies to the catapult and cannonball:

The catapult illustrates the law of conservation of energy because energy is never created or destroyed, only transformed from one energy to another. For example transferring from elastic energy to gravitational potential when the arm is raised up.

Use the kinematic equation to calculate the vertical velocity of the cannonball at the top of it's arc; use the parameters from lesson 2. The calculation for the initial vertical velocity components has already been started for you. Round the velocities to a whole number in your calculations.

Knowns:

$V_i = 28$ m/s

$a = 9.81 m/s^2$

$t = t/2 = 2.02$ s

$V_{iy} = V_i \sin(45)$

$V_{iy} = V_i \times 0.707$

$V_{iy} = 28\frac{m}{s} \times 0.707$

$V_{iy} = 19.8\frac{m}{s}$

$\boldsymbol{V_{fy} = V_{iy} + at}$

$V_{fy} = 19.796\frac{m}{s} + (-9.81\frac{m}{s})(2.02s)$

$V_{fy} = 19.8\frac{m}{s} - 19.8\frac{m}{s}$

$V_{fy} = 0$

Use the same formula to find thevertical acceleration of your cannonball from the top of its arc to the bottom of the parabola. The final velocity you calculated above is now your initial velocity. Round your final answer to the nearest tenth.

Knowns:

$V_i = 0$ m/s

$V_f = 28$ m/s

$t_i = 0$ s

$t_f = 2.02$ s

$V_{fy} = V_f \sin(-45)$

$V_{fy} = V_f \times -0.707$

$V_{fy} = 28\frac{m}{s} \times -0.707$

$V_{fy} = -19.8\frac{m}{s}$

Knowns:

$V_i = 0$ m/s

$V_f = 28$ m/s

$t_i = 0$ s

$t_f = 2.02$ s

$V_{fy} = V_f \sin(-45)$

$V_{fy} = V_f \times -0.707$

$V_{fy} = 28\frac{m}{s} \times -0.707$

$V_{fy} = -19.8\frac{m}{s}$

Was the vertical velocity at the midpoint you calculated close to zero m/s? What does your answer for the velocity reveal about the energy state of the ball? Will this always be the case?

The vertical velocity will always be zero at the peak of the trajectory. At this point the gravitational potential energy is equal to that of the vertical kinetic energy.

Is your answer for the vertical acceleration close to any significant value? What does your answer reveal about the movement of the ball in the vertical plane?

In the vertical direction there is a force acting on the ball which is known as gravity. The negative value of 9.81 shows that acceleration due to gravity is pulling the ball down for the entire path of the trajectory.

What is the minimum mass of the ball needed to knock over all the blocks? ***9.0 kg***
What is the minimum spring force value needed to knock over all the blocks? ***5500 N***