Activity worksheet: mechanical energy

Name	Group	Date

What you will learn

With the mechanical energy simulation you will ride a roller coaster and let go of a pendulum. You will see how the energy of height (potential) turns into the energy of movement (kinetic) and back again, you will check that their sum is conserved and you will find out where the energy goes when there is friction.

How to work. Each activity has three steps:

1. **Predict.** Before looking at the simulation, write down what you think will happen and why.
2. **Observe.** Set up the simulation, watch what happens and note down the data.
3. **Explain.** Compare what happened with your prediction and explain why.

If your prediction turns out to be wrong, don't rub it out: getting it wrong and understanding why is the best way to learn.

Each activity has a link that opens the simulation already set up. If you have the worksheet on paper, go to **simulaciencia.es/en/simulations/energia-mecanica** and set it up as described under “Set up the simulation”.

How to read the data. The “Real-time readings” panel gives the speed (v), the height (h) and the energies: kinetic (Ek, green), potential (Ep, blue) and mechanical (Em = Ek + Ep, yellow). With friction, heat appears (Q, orange). To read a value at a particular point, set the “Playback speed” to ×¼ and press “⏸ Pause” at that point.

Before you start

What do you think now? Write T (true) or F (false). You will come back to this table at the end.

Statement	T or F
a) A heavier car goes down the roller coaster faster.	
b) If the car reaches the valley very fast, it can climb higher than the point it started from.	
c) At the highest point of its swing, a pendulum has no energy.	
d) Even without friction, a pendulum ends up stopping.	
e) With friction, energy is used up and disappears.	

Activity 1. Height and speed

Set up the simulation: Roller coaster, classic track, start at **25 m**, no initial speed, **500 kg** car. Open the simulation ready to use

Predict. Where do you think the car will go fastest: at the top of a hill or in a valley? Why?

My prediction

Observe. Choose ×¼ and pause the car at each point in the table. Press "Velocity vector" to see the velocity arrow.

Point	Height h (m)	Speed v (m/s)	Ek (kJ)	Ep (kJ)	Em (kJ)
Start					
First valley					
Top of the 18 m hill					
4 m valley					

Explain.

1. What happens to the potential energy when the car goes down? And to the kinetic energy?
2. What is special about the last column? Write the principle you have checked.

My answers

Activity 2. Does mass matter?

Set up the simulation: Roller coaster, start at 25 m. Try a **100 kg** car and a **1000 kg** one. Open with 100 kg · Open with 1000 kg

Predict. Which of the two cars will reach the first valley faster? Which one will have more energy?

My prediction

Observe. Read the starting energy ("E initial") and pause in the first valley to read the speed.

Mass (kg)	E initial (kJ)	Speed in the first valley (m/s)
100		
1000		

Explain. Why does the 1000 kg car have ten times more energy but not go any faster? Use the formulas Ek = ½ · m · v² and Ep = m · g · h.

My explanation

Activity 3. Will it get over the hill?

Set up the simulation: Taller hill (27 m) profile, start at **25 m**, no initial speed and no friction. Open the simulation ready to use

Predict. The car reaches the valley very fast. Do you think it will be able to climb the 27 m hill and get to the other side?

My prediction

Observe. Look at how high the car climbs and at the yellow line “max. reachable height”. Then give it an initial speed with the slider.

Initial speed (m/s)	Does it get over the hill?	Maximum height it reaches (m)
0		
6.0		
6.5		

Explain.

1. Why does it not get over the hill if it starts from rest at 25 m?
2. Why can it get over with some initial speed? Where does the energy it was missing come from?

My answers

Activity 4. The pendulum

Set up the simulation: Pendulum mode, **2 m** string, initial angle of **45°** and a 1 kg bob, no friction. Open the simulation ready to use

Predict. At the highest point of the swing, what energy does the bob have? And at the lowest point? If there is no friction, will it ever stop?

My prediction

Observe. Pause at one end of the swing and at the lowest point. Then leave the pendulum for a minute at ×2.

Moment	Height h (m)	Speed v (m/s)	Ek (J)	Ep (J)	Em (J)
At one end					
At the lowest point					
After a minute: has the amplitude changed?					

Explain.

1. Is it true that there is no energy at the highest point? Which energy is zero there?
2. Look at the “Energy against time” graph. What are the Ek and Ep curves like? And the Em one?

My answers

Activity 5. Where does the energy go with friction?

Set up the simulation: Roller coaster, classic track, start at 25 m, 500 kg and **friction** with μ = 0.05. Open the simulation ready to use

Predict. With friction, how high will the car come back to? What will happen to the mechanical energy?

My prediction

Observe. Look at the energy bars, the yellow line and the graph. Write down the maximum height of each run and the “Energy balance” at the end of each one.

Run	Maximum height (m)	Ek + Ep (%)	Q (%)
1			
2			
3			

Explain.

1. Has the mechanical energy that the car loses disappeared? What has it turned into?
2. What do Ek, Ep and Q always add up to? Which principle holds?
3. Can that heat be used to lift the car up again? Why do we say that energy is degraded?

My answers

Activity 6. A roller coaster on the Moon

Set up the simulation: Roller coaster, start at 25 m, 500 kg and **Moon** gravity. Open on the Moon · Open on Jupiter

Predict. Will the car go faster or slower on the Moon than on Earth? And on Jupiter?

My prediction

Observe. Change the gravity and write down the starting energy and the speed in the first valley.

Place	g (m/s²)	E initial (kJ)	Speed in the first valley (m/s)
Earth	9.8		
Moon	1.62		
Mars	3.71		
Jupiter	24.79		

Explain. Why does the potential energy change when you change planet if the height and the mass are the same?

My explanation

Apply what you have learnt

Solve these without the simulation. Write the formula, the calculation with its units and the result. Use g = 9.8 m/s².

1. Calculate the potential energy of a 400 kg car at a height of 20 m.
2. That car starts from rest and there is no friction. At what speed does it reach a valley at 0 m? And a hill of 15 m?
3. A 0.5 kg pendulum is released from 0.30 m above its lowest point. At what speed does it pass through the lowest point?
4. A car has 100 kJ of mechanical energy at the start and 85 kJ at the end of the ride. How much work has friction done? What have those 15 kJ turned into?

Problem	Working and result
1	
2	
3	
4	

Review your ideas

Go back to the “Before you start” table. Would you change any of your answers? Write which one and explain why, using something you saw in the simulation.

What has changed in my ideas

Going further (Year 12)

1. In activity 3, calculate the minimum initial speed needed to get over the 27 m hill starting from 25 m. Check with the simulation that your result lies between the 6.0 and 6.5 m/s cases.
2. With the classic track and μ = 0.05, pause in the first valley and read Q. Calculate the work done by friction with $W_{fr} = \mu \cdot m \cdot g \cdot \Delta x$, where $\Delta x \approx 9.7$ m is the horizontal distance from the start to the valley, and compare.

3. In the pendulum with friction (b = 0.10 kg/s), compare what percentage of mechanical energy is left after 10 s with a 1 kg bob and with a 2 kg bob. Why is it not the same?

My answers

Self-assessment

Put an X to show how confident you feel at the end.

I can...	Yes	Nearly	Not yet
Calculate kinetic energy and potential energy			
Explain how potential energy turns into kinetic energy and back again			
Apply conservation of mechanical energy to calculate speeds and heights			
Explain what friction does to mechanical energy			
Use a prediction and an observation to change an idea I had			

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