

Finding energy efficiency of track

Hot Wheels tracks don't result in perfect "potential energy turns into kinetic energy" problems as there are a lot of other kinds of energy involved. We will try and take that into account by defining the tracks effeciency.

1. Set up the Hot Wheels track in the shape of a rounded "v" as shown above in Diagram 1. Use two pieces of track and the ramp connectors. Release the car from the top of the track and determine how high up on the other side the car goes. Measure to the middle of the car. Record the heights below. These are made up numbers

- 2. Why is the final height less than the initial height? Be cause the car lost sume of its energy to sound & heat
- 3. In terms of energy, where else does the initial potential energy of the car go? As the car goes down, PE turns into KE (+ sound, head, & KE of track moving) of an and etc.)

4. Determine the fraction of energy the car kept (i.e. the efficiency of the system) by dviding the Your #'s will be different! final height by the initial height.

$$\frac{.35}{.60} = .583 \qquad \text{efficiency} = \underline{58\%} \qquad \text{Efficiency is usually} \\ \text{between } \sim 30\% \quad \text{and } \sim 60\%$$

0.35

m

5. Why did you <u>not</u> need to know the mass of the car? wasn't part of calculation.

But that calculation was really from comparing the
initial § find PE!
so
$$\frac{mgh_f}{mgh_i} = \frac{h_f}{h_i}$$
 b/c m § g cancel out! side 1

Lab 9-2: Hot Wheels

NAME: ____

Finding minimum speed to just barely make the loop

First we will do some math and circular motion concepts to figure out how fast the car has to be moving to just barely make the loop.

6. Set up the Hot Wheels track to make a loop-the-loop (Diagram 2.) Secure the track with some tape and a stand. When it is all put together, measure the radius of the loop.

radius of loop = 0.11 m It should be ~ 11 or 12 cm Now we (meaning you) have to do some algebra. When the car is at its highest point on the loop 7 it is upside down. There are two forces acting on the car at that point - draw a labeled force diagram that shows those two forces. F_N Normal Force (track pushing down on car) F_g weight of Car (mg) In what direction is the net force and on the car at its highest point on the loop? How do you 8. know? because it is directed to the center of the circle, DOWN which is under the car. There are two ways you can figure out the net force (combining question 7 and question 8 with your knowledge of the net force when an object is moving in a circle.) Write it out below as an equation. () $\Sigma F = F_N + F_g$ (just add up the forces) (2) $\Sigma F = \frac{mV^2}{r}$ (centripetal force) So | FN + Fg = 10. Hopefully your answer to question 9 says something like the weight of the car plus the normal force on the car equals the centripetal force on the car. Here is an important idea: what is the normal force on the car at the top of the loop if the car just barely makes the loop? Ful= 0 for car to just barely make the loop.

11. So what happens to your equation from question 9? Write it out below.

 $F_N = 0$ $F_N + F_g = \frac{mv^2}{r} \rightarrow mg = \frac{mv^2}{r}$ Notice "m" will cancel again!

12. If you did everything correctly, your equation in step 11 should say the weight of the car (mg) equals the centripetal force on the car (mv^2/r). Plug in radius of your loop, the acceleration due to gravity and solve the speed. This is the speed the car needs to have at the top of the loop to just barely make the loop.

 $p_1 g = p_1 v^2$ $V^2 = (.11) g = (.11)(10)$ $V^2 = 1.1$ V = 1.05 m/5speed at top of loop = $\frac{1.05}{m/s}$

Lab 9-2: Hot Wheels

NAME:

Finding minimum release height for car to make the loop

Now we will use energy ideas to figure out where the car needs to be released so that the car makes the loop.

13. Using letters, what would be the initial energy of the car while you are holding it up on the ramp?

$$E_i = Mgh_i$$

 S_0 Total Enitial Energy = Mgh_i
 $KE_i = 0$ (ΣE_i)

14. Using letters, what would be the final energy of the car when it is at the top of the loop? (*Hint:* there are two types of energy!)

$$PE_{f} = mgh_{f} \qquad s_{0} \qquad \Sigma E_{f} = mgh_{f} + \frac{1}{2}mv_{f}^{2}$$

$$KE_{f} = \frac{1}{2}mv_{f}^{2}$$

15. Since energy is conserved, combine your answers to 13 and 14 into an equation.

$$prigh_i = prigh_f + \frac{1}{2}priv_f$$

- 16. Notice the mass of the car cancels out. What is the height of the car when it is at the top of the loop?
- ht = twice the radius

height at top of loop =
$$0.22$$
 m

- Again, use your #s
- 17. Now plug in the height at the top of the loop, the speed at the top of the loop and the acceleartion due to gravity and solve for the initial height of the car.

$$gh_{i} = gh_{f} + \frac{1}{2}V_{f}^{2}$$

$$(10) h_{i} = (10)(.22) + \frac{1}{2}(1.05)^{2}$$

$$ID h_{i} = 2.75$$

$$h_{i} = .275$$

if you did it correctly)

19. Thinking about energy, why do you think the car did not make the loop?

Lab 9-2: Hot Wheels

20. The car didn't make the loop because it "lost" a lot of the potential energy it had at the start to other forms of energy. We didn't take into account the efficiency of the track. So let's fix that now by using the following to more accurately predict the minimum height so that the car makes the loop:

theoretical minimum height = efficiency of system x predicted minimum height

(You calculated at the efficiency at the start of this lab.)

(.275) = (.58) h so h = 0.47 m

predicted minimum release height = 0.47 m

21. Release the car from that predicted height. What happens?

I don't know what happened in your lab - hopefully it worked :

22. Finally, experimentally figure out the minumum release height so that the car just barely makes the loop.

actual minimum release height = _____ m

23. Did physics work?

The answer to #20 is usually pretty close to the answer to #22 (within a few centimeters)