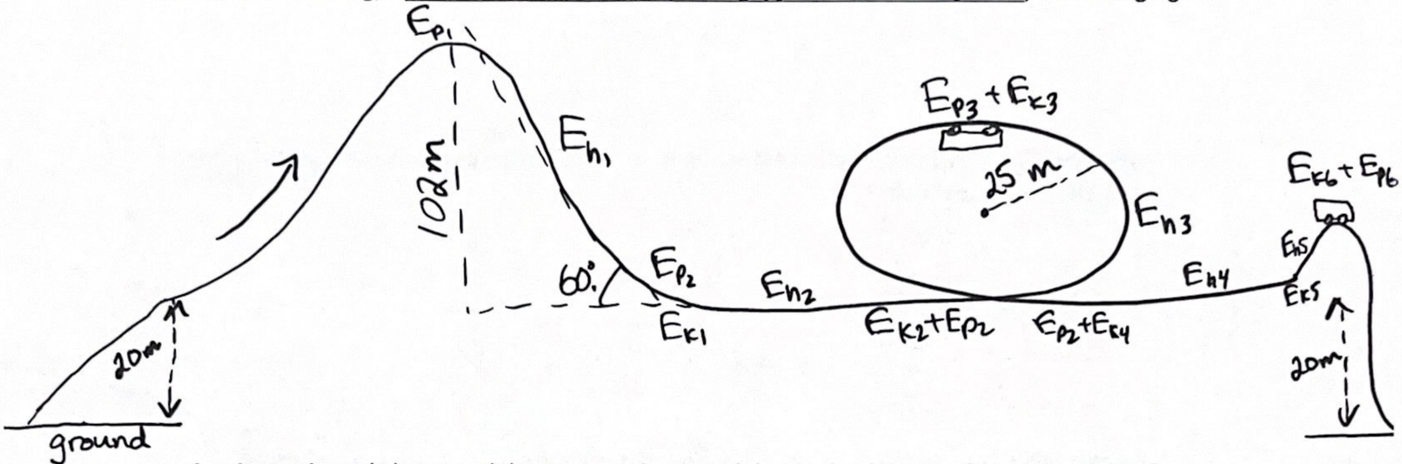
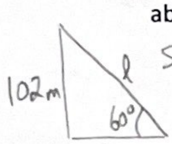
Pre-"Roller Coaster Project" Practice Name: Key

Details: Car = 500.kg, ***367J energy lost to heat (average) for each meter of track,*** use 2 sig figs



1. Approximately how much heat energy is created during the descent of a car down the slope above (assuming an average of 367J heat created per meter all the way through the ride)? (answers)



$\sin 60° = \frac{102m}{l}$

$l = 117.779m$

$E_{h1} = (367\frac{J}{m})(117.779m)$

$= 43225J = \underline{4.3\times10^4 J}$

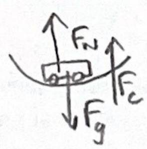
2. If the car has 600,000.J of potential energy at the top of the first hill, how fast will it be moving at the bottom of the hill?

$600{,}000J - E_{h1} = E_{p2} + E_{k1}$

$600{,}000J - 43225J = (500kg)(9.81\frac{N}{kg})(20m) + \frac{1}{2}(500)v_1^2$

$v = 42.833\frac{m}{s} = \underline{43 m/s}$

3. What would the g-force be in the curve at the bottom of the hill if the radius of the curve is 30.m?



$F_c = F_N - F_g$

$F_N = F_c + F_g = \frac{mv^2}{r} + mg = \frac{500(42.833)^2}{30m} + 500(9.81)$

$= 35483.\bar{3}N$

$\text{g-force} = \frac{F_N}{F_g} = \frac{35483.\bar{3}}{500(9.81)}$

$= \underline{7.2}$

4. As the car enters the vertical loop, it is moving at 41.8m/s. The loop has a radius of 25m (and is 20.m above ground), how much kinetic energy will the car have at the top of the loop? (assumed to simplify this worksheet)

Bottom $- E_{h3} =$ Top

$E_{p2} + E_{k2} - E_{h3} = E_{k3} + E_{p3}$

$E_{k3} = E_{p2} + E_{k2} - E_{h3} - E_{p3}$ (half circumference of loop)

$= (500)(9.81)(20m) + \frac{1}{2}(500)(41.8\frac{m}{s})^2 - \frac{1}{2}2\pi(25)(367\frac{J}{m}) - 500(9.81)(70m)$

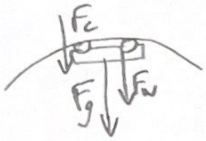
$= 162736J \rightarrow \underline{1.6\times10^5 J}$

5. How fast is the car moving at the top of the loop?

$E_{k_3} = 162736\,J = \frac{1}{2}(500\,kg)(v)^2$

$v = 25.514 = \underline{26\,m/s}$

6. What is the minimum speed needed at the top of the loop for the people to not fall out of the car? Do they need seat belts?



$F_c = F_g + F_N$ (0)

$\frac{mv^2}{r} = mg$

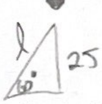
$v = \sqrt{rg} = \sqrt{(25\,m)(9.81\,\frac{N}{kg})} = 15.66 = \underline{16\,m/s}$

No seatbelt needed, going faster than minimum needed

7. If the next hill is 45m tall (from the ground), how fast will the car be moving at the top of it? (Assume the car has a speed of 38m/s at the bottom of the hill and the hill has a 60.° slope.)

Bottom $- E_h =$ Top $\longrightarrow$ $E_{k5} + E_{p2} - E_{h5} = E_{k6} + E_{p6}$

$\frac{1}{2}(500)(38)^2 + 500(9.81)(20\,m) - 28.868(367\,\frac{J}{m}) = \frac{1}{2}(500)v_5^2 + 500(9.81)(45)$



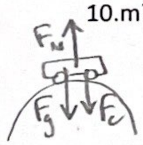
$\sin 60° = \frac{25}{l}$

$l = 28.868$

$v_5 = 30.18\,m/s$

$= \underline{30.\,m/s}$

8. What is the maximum speed for people to not fly out of the car if the radius of the curve is 10.m? Do they need seat belts?



$F_c = F_g - F_N$ (0)

$\frac{mv^2}{r} = mg$

$v = \sqrt{rg} = \sqrt{(10\,m)(9.81)} = \underline{9.9\,m/s}$

Yes, need seatbelts, going too fast, will fly out due to inertia without seatbelts

9. If there were a horizontal loop of radius 65m, how many g-forces would people feel halfway through assuming they are travelling at 35m/s at that point in the loop.

(WB pg51)

$F_c = F_N$

$\frac{mv^2}{r} = F_N = \frac{(500)(35\,m/s)^2}{65\,m} = 9423\,N$

$g\text{-force} = \frac{F_N}{F_g} = \frac{9423\,N}{(500)(9.81)} = \underline{1.9}$

10. If the whole roller coaster track is 1500m long, and ends at ground level, how much energy would be left and what coefficient of friction would be required to stop the car along a flat 50.m stretch?

$600{,}000\,J - 1500\,m(367\,\frac{J}{m})$

$= \underline{49500\,J}$

(need to get rid of this energy thru friction)

$E_h = F_f d$

$= \mu F_N d$

$= \mu F_g d$

$\mu = \frac{E_h}{F_g d} = \frac{49500\,J}{(500)(9.81)(50\,m)} = \underline{0.20}$