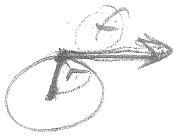
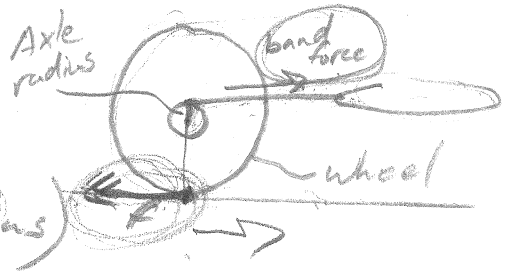
Rubber Band Car Practice Quiz





1. $\tau = Fr$

Max torque = (max rubber band force)(Axle radius)

$= (35N)(0.002m) = 0.07N \cdot m$

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2. Friction between wheels & road = 1.2N

"traction"

↑ will not be on quiz

If the wheel pushes the road with more force than this, it will slip.

$\tau = 0.07N \cdot m$ (from #1)

wheel radius giving this force

1.2N (The largest force that the wheel can push against the road without slipping

$$r = \frac{\tau}{f} = \frac{0.07N \cdot m}{1.2N} = 0.583\overline{3}\,m$$

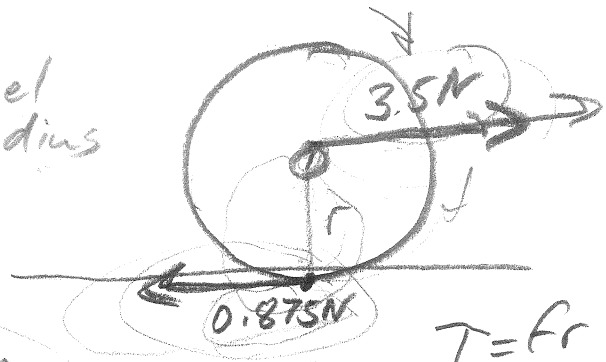
$$f = \frac{\tau}{r} = \frac{0.07N \cdot m}{0.4m}$$

3. τ / F | r

$f = \frac{\tau}{r}$ ← max torque (from #1)

r ← wheel radius

f ↑ max force exerted by edge of wheel



$\tau = fr$

$f = \frac{\tau}{r} = \frac{0.07 N \cdot m}{0.08 m} = 0.875 N$

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4. $\frac{\text{Mass in grams}}{1000 \frac{g}{kg}} = \text{mass in kg}$

$\frac{160 g}{1000 g/kg} = 0.16 kg$

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5. F / m | a

$a = \frac{F}{m}$ ← max force of wheels pushing road backward = force of road pushing car forward

m ← Car mass (kg)

$a = \frac{0.875 N}{0.16 kg} = 5.47 m/s^2$

6. $\text{average force} = \frac{\text{min force} + \text{max force}}{2} = \frac{35N + 5N}{2} = 20N$

7. $\text{Work} = fd = 20N(0.35m) = 7j$

average force of bands

Stretch Distance of bands

Work ≈ Energy

Work = ΔEnergy

8. $PE_{\text{in bands}} = \text{Work done on bands during stretching}$

$PE_{\text{in bands}} = 7j$ (from #7)

9. $\text{time} = \frac{\text{frames elapsed}}{\text{frame rate (frames per second)}} = \frac{18 \text{ frames}}{240 \text{ frames/sec}} = 0.075s$

10. $1 \text{ foot} = 0.305m = 1 \text{ floor tile}$

11. $V = \frac{d}{t}$ ← length of a floor tile; ← shortest time to cross a floor tile; ↑ maximum

$V = \frac{0.305m}{0.075s} = 4.07m/s$

12. $\text{Max } KE = \frac{1}{2} m v^2$ (m: car mass in kg; v: max velocity)

$\text{Max } KE = \frac{1}{2}(0.16kg)(4.07m/s)^2$

$KE_{max} = 1.32j$

13. $\text{Efficiency} = \frac{\text{Energy Output}}{\text{Energy Input}} \times 100\%$

KE from #12

Energy put into rubber bands, from # 7 or 8

$\text{Efficiency} = \left(\frac{1.32\text{ J}}{7\text{ J}}\right) 100\%$.

$\text{Effic.} = 18.9\%$.

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14. $PE = mgh$ (m = mass in kg; g = acceleration of gravity = 10 m/s^2; h = height at top of ramp)

$PE = (0.16\text{ kg})(10\text{ m/s}^2)(0.3\text{ m})$

$PE = 0.48\text{ J}$ at top of ramp

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15. $d_{\text{meters}} = d_{\text{floor tiles}}\left(0.305\frac{\text{m}}{\text{foot}}\right)$ (feet)

$\text{distance} = 24\text{ feet}(0.305\text{ m/foot}) = 7.32\text{ m}$

16+17. Work done by friction = PE that was originally stored in car at top of ramp.

$W = 0.48\text{ J}$ from #14

$W = Fd$, $F = \frac{W}{d}$ (F = force of friction; d = distance over which cart is rolling and friction is acting)

$W = PE$, and $F = \frac{W}{d}$, so $F = \frac{PE}{d}$

$F = \frac{0.48\text{ J}}{7.32\text{ m}} = 0.066\text{ N}$ (0.48 J ← #14; 7.32 m ← #15; F = friction)

18. Output energy of a car is its KE.

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(0.16\,kg)(16\,m/s)^2$

$KE = 20.48\,J$

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19. $\text{Input Energy} = \frac{\text{Energy Output}}{\text{Efficiency}}\ (100\%)$ ← #18, ← #13

$\text{Input Energy} = \frac{20.48\,J\ (100\%)}{18.9\%} = 108\,J$

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20. + 21. $\text{Input energy} = \text{Work stretching bands} = (\text{force})(\text{distance})$

$108\,J$ = (Average band force)(stretch distance)

So

$108\,J = (\text{force})(\text{distance})$

These can be any two numbers that have a product equal to 108 J. It's easiest to pick one number and solve for the other.

$W = Fd$, so $F = \frac{W}{d} = \frac{108\,J}{d}$

If $d = 2m$, then $F = \frac{108\,J}{2m} = 54\,N$