Physics 100 Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Rubber Band Cars

Work and Energy

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**Torque** = (force) x (radius)

**T = fr**

**Work** = (force) x (distance)

**W = fd**

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**Work ≈ energy input**

**Kinetic Energy = KE = ½ mv2**

**V = sqrt(2\*KE/m)**

**Energy Efficiency = (Energy Output / Energy Input) x 100%**

**Energy Input = (Energy Output\*100) / Efficiency**

**Energy Output = Efficiency \* Energy Input/100**

**Potential Energy = PE = mgh**

**g ≈ 10m/s2**

**F = ma a =F/m**

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| **Problem Set #1: Consider a rubber band car with these attributes...**  |
|   | Axle radius (m) | 0.0019 |
|   | Wheel radius (m) | 0.05 |
|   | Rubber Band Maximum Force (N) | 40 |
|   | Rubber Band Minimum Force (N) | 4 |
|   | Rubber Band Stretch Distance (m) | 0.12 |
|   | Car mass (g) | 110 |
|   | Maximum Measured Velocity (m/s) | 3.4 |
|   | Distance rolled when released from a 0.5m tall ramp (floor tiles) | 36 |
|   |   |   |
| **1** | What is the maximum torque on the car's drive wheels and axle? (N•m) |   |
| **2** | What is the maximum force with which the car pushes backward against the road? (N) |   |
| **3** | What is the car's mass, in kg -- 1kg = 1000g (kg) |   |
| **4** | Based on this maximum force of the car pushing the road backward, and assuming that the wheels do not slip, what should be the car's maximum acceleration? (m/s^2) |   |
| **5** | What is the average rubber band force? (N) |   |
| **6** | How much work is done in stretching the rubber band during the winding of the car's motor? (j) |   |
| **7** | How much energy is put into the car when the car is wound up? (j) |   |
| **8** | What is the car's maximum kinetic energy? (j) |   |
| **9** | What is the car's efficiency? (%) |   |
| **10** | How much Potential Energy did the car have when it was held at the top of the ramp? Use g=10m/s^2. (j) |   |
| **11** | How far did the car roll horizontally when it was allowed to roll down the ramp and onto the floor? Each floor tile is 0.305m (m) |   |
| **12** | How much work did friction do in the process of bringing the car to a stop? (j) |   |
| **13** | What was the force of "rolling friction" that brought the car to a stop? (N) |   |

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| **Problem Set #2: Consider a rubber band car with these attributes...**  |
|   | Average Rubber Band Force (N) | 15 |
|   | Rubber Band Stretch Distance (m) | 0.4 |
|   | Car mass (g) | 160 |
|   | Efficiency (%) | 25 |
|   |   |   |
| **1** | What is the car's mass, in kg? (kg) |   |
| **2** | What is the car's energy input? (j) |   |
| **3** | Based on the car's efficiency, what is the car's likely energy output? (j) |   |
| **4** | Based on that output, what is the car's expected maximum velocity? (m/s) |   |
| **5** | What would the car's energy input be if everything were kept the same, but the average rubber band force were doubled? (j) |   |
| **6** | At the same efficiency and the input energy from the previous question, what energy output could be expected? (j) |   |
| **7** | With the energy output from the previous question, what is the car's expected maximum velocity? (m/s) |   |
| **8** | What would the car's energy input be if everything were kept the same, but the average rubber band force were tripled (j) |   |
| **9** | At the same efficiency and the input energy from the previous question, what energy output could be expected? (j) |   |
| **10** | With the energy output from the previous question, what is the car's expected maximum velocity? (m/s) |   |
| **11** | In order to achieve a velocity of 10m/s, how much output energy would the car need? (j) |   |
| **12** | At the efficency listed above, how much input energy would be needed? (j) |   |
| **13** | Given the stretch distance listed above, how much rubber band force would be required in order to give the car the input energy from the previous question? (N) |   |
| **14** | Given the average rubber band force listed above, how muchstretch distance would be required in order to give the car the input energy from question #12? (m) |   |

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| **Problem Set #3: Consider a rubber band car with these attributes...**  |
|   | Axle radius (m) | 0.003 |
|   | Wheel radius (m) | 0.09 |
|   | Rubber Band Maximum Force (N) | 35 |
|   | Rubber Band Minimum Force (N) | 2 |
|   | Rubber Band Stretch Distance (m) | 0.46 |
|   | Car mass (g) | 140 |
|   | Maximum Measured Velocity (m/s) | 6.4 |
|   | Distance rolled when released from a 0.5m tall ramp (floor tiles) | 25 |
|   |   |   |
| **1** | What is the maximum torque on the car's drive wheels and axle? (N•m) |   |
| **2** | What is the maximum force with which the car pushes backward against the road? (N) |   |
| **3** | What is the car's mass, in kg? |   |
| **4** | Based on this maximum force of the car pushing the road backward, and assuming that the wheels do not slip, what should be the car's maximum acceleration? (m/s^2) |   |
| **5** | What is the average rubber band force? (N) |   |
| **6** | How much work is done in stretching the rubber band during the winding of the car's motor? (j) |   |
| **7** | How much energy is put into the car when the car is wound up? (j) |   |
| **8** | What is the car's maximum kinetic energy? (j) |   |
| **9** | What is the car's efficiency? (%) |   |
| **10** | How much Potential Energy did the car have when it was held at the top of the ramp? Use g=10m/s^2. (j) |   |
| **11** | How far did the car roll horizontally when it was allowed to roll down the ramp and onto the floor? Each floor tile is 0.305m (m) |   |
| **12** | How much work did friction do in the process of bringing the car to a stop? (j) |   |
| **13** | What was the force of "rolling friction" that brought the car to a stop? (N) |   |

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| **Problem Set #4: Consider a rubber band car with these attributes...**  |
|   | Average Rubber Band Force (N) | 10 |
|   | Rubber Band Stretch Distance (m) | 0.25 |
|   | Car mass (g) | 98 |
|   | Efficiency (%) | 20 |
|   |   |   |
| **1** | What is the car's mass, in kg? (kg) |   |
| **2** | What is the car's energy input? (j) |   |
| **3** | Based on the car's efficiency, what is the car's likely energy output? (j) |   |
| **4** | Based on that output, what is the car's expected maximum velocity? (m/s) |   |
| **5** | In order to achieve a velocity of 10m/s, how much output energy would the car need? (j) |   |
| **6** | At the efficency listed above, how much input energy would be needed? (j) |   |
| **7** | Given the stretch distance listed above, how much rubber band force would be required in order to give the car the input energy from the previous question? (N) |   |
| **8** | Given the average rubber band force listed above, how muchstretch distance would be required in order to give the car the input energy from question #6? (m) |   |