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- 1) (25 points) A puck of mass  $M = 24.0\text{kg}$  is sliding on a frictionless surface at a speed  $V=4.50\text{ m/s}$  in the x-direction and hits another puck of mass  $m = 11.0\text{kg}$  at rest at the origin. The collision lasts  $0.004\text{s}$ . The smaller mass leaves the collision at an angle of  $40$  degrees above x-axis and the larger at an angle of  $25$  degrees below the x-axis.
- What are the final speeds of the particles?
  - What is the total change in kinetic energy during the collision?
  - Is the collision elastic?
  - What is the impulse applied to the smaller particle?
  - What is the average force?

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- 2) (25 points) You decide to build a  $\frac{1}{4}$  scale racetrack in your backyard.
- a) You start with a flat track with 20m radius curves. On a dry sunny day you determine that your miniature racecar skids off the curves at a speed of 5.1m/s. What is the static coefficient of friction  $\mu_s$  between the tires and the road?
  - b) In order to go faster and be safer on rainy and icy days you decide to bank the curves. What angle  $\beta$  should you bank the curves so that you can still safely use your track at a speed of 5 m/s on the iciest days when  $\mu_s=0$ ?
  - c) At the angle found in part b how much faster can you go on a dry day when  $\mu_s$  is what you determined in part a. (If you could not do parts a or b then use  $\mu_s=.1$  and  $\beta=10$  degrees for this problem.)

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- 3) (25 points) You are a 50kg coyote named Wile E. You are trying to catch the Road Runner (a small bird). You place a small pile of birdseed at the base of a 100m vertical cliff to lure the bird. Then you climb to the top of the cliff. Once there you pull a 200kg anvil to the top using a mass-less rope and friction-less pulley. Your plan is to drop the anvil on the Road Runner when he stops to eat the birdseed.
- a) How much work is done pulling the anvil to the top of the cliff?
  - b) If it required an average of 50 W of power, how long did it take to reach the top?
  - c) How much potential energy did the anvil gain when you pulled it up to the top of the cliff?
  - d) When Road Runner stops to eat the birdseed you release the anvil. Unfortunately the rope gets caught on your foot. When the anvil has fallen half way down the cliff (50m) the rope becomes tight and starts to pull you over the cliff. At this point what is the speed of the anvil?
  - e) You dig your heels in to create friction ( $\mu_k=0.5$ ), but you are pulled 10m to the edge of the cliff. At this point what is the speed of the anvil?
  - f) Then you fall over the edge of the cliff. What is the speed of the anvil when it hits the ground?
  - g) What is your speed when you hit the ground?

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- 4) (25 points) You drop a 10kg mass from rest at a height of 1m above the top of a mass-less spring, which obeys Hooke's Law. Ignore air friction for parts a-c.
- If the maximum compression of the spring is 3cm, what is the spring constant of the spring?
  - What is the speed of the mass when the spring is compressed 1 cm?
  - How high will the mass go as it returns from the spring? (Note: the mass leaves the spring when the spring is uncompressed.)
  - If we do ***not*** ignore air friction and the mass returns to a point 2cm below the point that you dropped it, what is the work done by the air friction on the mass? Is work positive or negative?
  - In part d), what is the change in internal energy of the air? Is the change positive or negative?