

Celebration #2: Newton's Laws II, Energy, Momentum, and Rotations

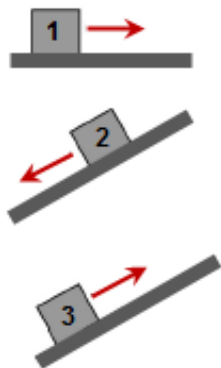
Short Answer Questions (5 points each)

1) It used to be common wisdom to build cars to be as rigid as possible to withstand collisions. Today, though, cars are designed to have "crumple zones" that collapse upon impact. What advantage does this have? *Explain your answer using physics principles.*

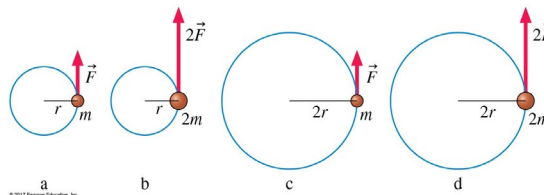
2) When an object's kinetic energy is increasing, must its potential energy be decreasing? *Explain your answer.*

3) A physics nerd is whirling a stone around their head in a horizontal circle by means of a massless string. The stone makes one complete revolution every 1.50 seconds, and the tension in the string is 15.0 N. The nerd then speeds up the stone, keeping the radius of the circle unchanged, so that the stone now makes one complete revolution every 0.90 seconds. What is the tension in the string now? *Justify your answer.*

4) The figure shows three situations involving a plane that **is not** frictionless and a block sliding along the plane. The block begins with the same speed in all three situations and slides until the kinetic frictional force has stopped it. **(a)** Which situation results in the greatest increase in thermal energy due to the sliding. **(b)** Which situation results in the smallest increase in thermal energy? Briefly **explain** your reasoning.



5) Rank in order, from largest to smallest, the angular accelerations α_a to α_d in the figure. *Justify your answer.*

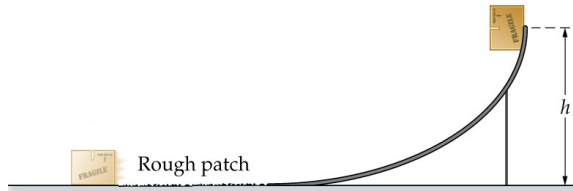


6) How much work is done when a force $\vec{F} = (2.0N)i - (5.25N)j - (6.55N)k$ acts on a 12.50 kg object over a displacement of $\Delta\vec{r} = (7.65m)j - (2.31m)k$?

Problems (10 points each)

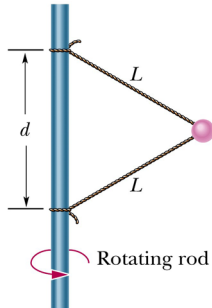
Problem 1

A 7.50 kg block is released from rest on top of a frictionless ramp of height $h = 3.25$ m as shown in the figure below. The block reaches the bottom of the ramp and then moves across a long rough surface. If the coefficient of kinetic friction between the rough patch and the block is $\mu_k = 0.315$, how far along the rough patch has the block traveled when its speed has decreased to 1.55 m/s?



Problem 2

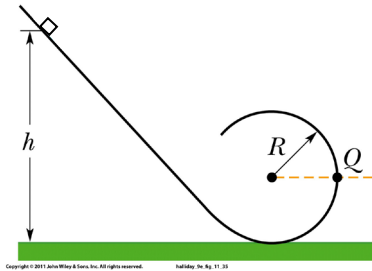
In the figure below, a 1.34 kg ball is connected by means of two massless strings, each of length $L = 1.70$ m, to a vertical, rotating rod. The strings are tied to the rod with separation $d = 1.70$ m and are taut. The tension in the upper string is 35.0 N. What are the **(a)** tension in the lower string and **(b)** the speed of the ball?



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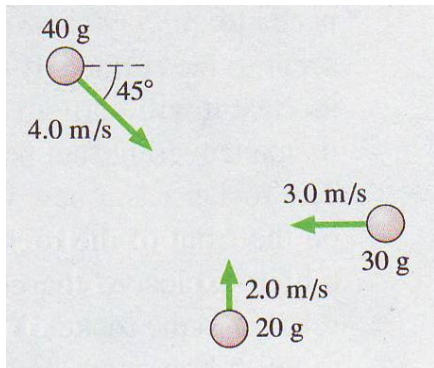
Problem 3

In the figure below, a kangaroo (brilliantly disguised as a box of mass 12.5 kg) slides without friction along a loop-the-loop track when released from rest from height h . The circular loop has radius $R = 14.0$ cm. **(a)** What is h if the kangaroo is on the verge of leaving the track when it reaches the top of the loop? **(b)** If the kangaroo is instead released from height $h = 7.50 R$, what is the magnitude of the normal force acting on the kangaroo at point Q?



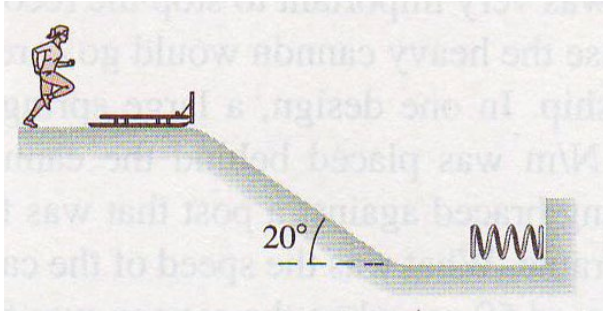
Problem 4

The figure below shows a collision between three balls of clay. The three balls hit simultaneously and stick together. What is the speed of the three balls after the collision?



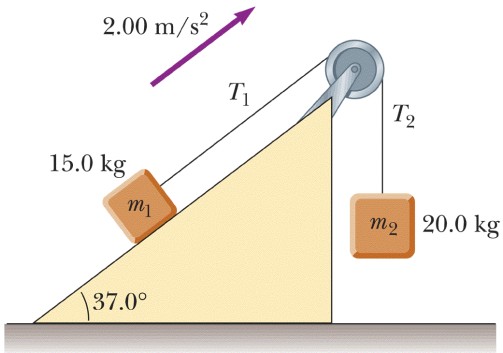
Problem 5

A new event has been proposed for the next Winter Olympics. As seen in the figure below, an athlete will sprint 100 m, starting from rest, then leap on a 25.0 kg bobsled. The person **and** bobsled will then slide down a 50.0 m long ice-covered (frictionless) ramp, sloped at 20.0° , and into a spring with a carefully calibrated spring constant of 2000.0 N/m. The athlete who compresses the spring the farthest wins the gold medal. Lisa, whose mass is 40.0 kg, has been training for this event. She can reach a maximum speed of 12.0 m/s in the 100 m dash. How far will Lisa (and the bobsled) compress the spring?



Problem 6

Two blocks, with masses $m_1 = 15.0 \text{ kg}$ and $m_2 = 20.0 \text{ kg}$, are connected by a massless, stretchless string passing over a frictionless pulley of radius 12.5 cm . The coefficient of kinetic friction between block m_1 and the incline is $\mu_k = 0.22$. Block m_1 is moving up the incline with a constant acceleration of 2.00 m/s^2 as shown in the figure below. What is the moment of inertia of the pulley? (**Note:** do not assume the pulley is a disk.)



7) A 20.0-gram block is placed against the free end of a spring of spring constant $k = 25.0 \text{ N/m}$ that is compressed by 15.0 cm. Once released, the block slides 1.25 m across the tabletop (that is 1.0 m high) and eventually lands 1.60 m from the edge of the table as shown in the figure below. What is the coefficient of kinetic friction between the block and the tabletop? (**Note:** the 1.25-m sliding distance along the tabletop includes the 15.0-cm compression of the spring. Assume that air resistance is negligible.)

