20. A safety mechanism will bring a saw blade rotating at 1500 rpm to rest in 0.3 seconds if the carpenter's hand comes off the saw controls.
   a. What angular acceleration does this require? [2]
   \[
   \alpha(t) = \frac{d\omega}{dt} = \frac{-523}{0.3} \text{ rad/s}^2
   \]
   b. How many complete revolutions will the saw blade make in this time? [3]
   \[
   \theta = \frac{\omega_0 + \omega}{2} \cdot t
   \]

21. A ski lift carries skiers along a 600 meter slope inclined at 30°. To lift a single rider, it is necessary to move 70 kg of mass to the top of the lift. Under maximum load conditions 350 riders per minute arrive at the top. If 60 percent of the energy supplied by the motor goes to overcoming friction, what average power must the motor supply?
   \[
   W = Fd \text{ or } W = \Delta E_{\text{p}}
   \]
   \[
   \left(\frac{700 \text{ in}}{30^\circ}\right) \left(600 \text{ m}\right)
   \]
   \[
   \left(70 \text{ kg}\right) \left(10 \text{ m/s}\right) = 21,000 \text{ J per mwn}
   \]
   \[
   P = \frac{W}{t} = \frac{21,000 \text{ W}}{40 \% \text{ of total power}} = 21,000 \text{ W}
   \]
   \[
   \frac{40}{100} \text{ of total power} = 21,000 \text{ W}
   \]

22. A block of mass M is resting on a horizontal, frictionless table and is attached as shown above to a relaxed spring of spring constant k. A second block of mass 2M and initial speed \( v_0 \) collides with and sticks to the first block. Develop expressions for the following quantities in terms of \( M, k, \) and \( v_0 \).
   a. Find the speed of the blocks immediately after impact
   Conservation of momentum
   \[
   P_{\text{block1}} = P_{\text{block2}} + P_{\text{transit}} + P_{\text{spring}}
   \]
   \[
   2m v_0 = (m + 2m) v_f + \frac{1}{2} k x^2
   \]
   \[
   2m v_0 = 3x v_f
   \]
   b. Find the maximum distance the spring is compressed.
23. Block A of mass 2.0 kg and block B of mass 8.0 kg are connected as shown above by a spring of spring constant 80 N/m and negligible mass. The system is being pulled to the right across a horizontal frictionless surface by a horizontal force of 4.0 N, as shown, with both blocks experiencing equal constant acceleration.

(a) Calculate the force that the spring exerts on the 2.0 kg block.

\[ F_A = \frac{4N}{m} = 4N \]

\[ F_A = 4N \]

(b) Calculate the extension of the spring.

\[ \frac{F_A}{k} = x \]

\[ \frac{4N}{80N/m} = x \]

\[ x = 0.05m \]

The system is now pulled to the left, as shown below, with both blocks again experiencing equal constant acceleration.

(c) Is the magnitude of the acceleration greater than, less than, or the same as before?

Greater \( \checkmark \) Less \( \checkmark \) The same

Justify your answer.

same net force of 4N on system and same total mass so same \( a \).

(d) Is the amount the spring has stretched greater than, less than, or the same as before?

Greater \( \checkmark \) Less \( \checkmark \) The same

Justify your answer.

(e) In a new situation, the blocks and spring are moving together at a constant speed of 0.50 m/s to the left. Block A then hits and sticks to a wall. Calculate the maximum compression of the spring.

\[ \frac{1}{2}kx^2 = \text{PE} \]

\[ \frac{1}{2}(80)(.5^2) = \frac{1}{2}(80)(x^2) \]

\[ 2 = 80 \times \frac{x^2}{80} \]

\[ x = 0.16m \]
24. An incident ball A of mass 0.10 kg is sliding at 1.4 m/s on the horizontal tabletop of negligible friction as shown above. It makes a head-on collision with a target ball B of mass 0.50 kg at rest at the edge of the table. As a result of the collision, the incident ball rebounds, sliding backwards at 0.70 m/s immediately after the collision.

a. Calculate the speed of the 0.50 kg target ball immediately after the collision.

Conservation of momentum:
\[ p_A - p_B = p_A + p_B \]
\[ (0.1)(1.4) = (0.1)(-0.7) + (0.5)(v) \]

b. Determine if the collision was elastic.

\[ \frac{KE_A}{KE_A + KE_B} = \frac{1}{2} = 0.50 \]
\[ v = \sqrt{0.42 \text{ m/s}} \]

\[ \frac{0.098}{0.69} \neq 0.169 \text{ (not elastic)} \]

c. Calculate the speed of the 0.50 kg ball when it hits the floor.

\[ p_t + KE_f = KE_f \]
\[ mgh + \frac{1}{2}mv_0^2 = \frac{1}{2}mv_f^2 \]
\[ (10)(1.2) + \left(\frac{1}{2}\right)(0.42)^2 = \frac{1}{2}v_f^2 \]

\[ v_f = 4.9 \text{ m/s} \]
25. A block is released from rest at the top of a curved incline in the shape of a quarter of a circle. The block then slides onto a horizontal plane where it finally comes to rest a distance $d$ from the beginning of the plane. The curved incline is frictionless, but there is a force of friction on the block while it slides horizontally and the coefficient of friction between block and surface is $\mu$. In terms of $\mu$, $d$ and $g$, determine the following:

[a] the speed of the block when it first enters the horizontal surface, $[2]$

\[
\frac{1}{2} m v^2 = m g h = \frac{1}{2} g \left( \frac{2 mg d}{g} \right) = \mu d
\]

[b] the height that the block was released from the top of the curved incline. $[2]$

\[
v = \sqrt{2 g h}
\]

26. Pulley A rotates clockwise at a constant angular velocity, driving a second larger Pulley B using a flexible belt moving around the two pulleys without slipping. The radius $r_A$ for Pulley A is half of the radius $r_B$ of Pulley B.

(a) Is the magnitude of the angular velocity of Pulley A greater than, less than, or equal to the magnitude of the angular velocity of Pulley B? Explain.

(b) Is the magnitude of the linear velocity of a point on the edge of Pulley A greater than, less than, or equal to the magnitude of the linear velocity of a point on the edge of Pulley B? Explain.

The smaller pulley has to make more rotations per second to have same linear speed as the larger pulley which has a bigger radius.

The belt must all be traveling together at the same speed otherwise if the front side goes faster the belt break and if slower, it bunches up.
27. From the top of a cliff 80 meters high, a ball of mass 0.4 kilogram is launched horizontally with a velocity of 30 meters per second at time \( t = 0 \) as shown above. The potential energy of the ball is zero at the bottom of the cliff. Use \( g = 10 \) meters per second squared.

a. Calculate the potential, kinetic, and total energies of the ball at time \( t = 0 \) [3]

\[
PE = mgh = (0.4)(10)(80) = 320 \text{ J}
\]

\[
KE = \frac{1}{2}mv^2 = (0.4)(30)^2 = 180 \text{ J}
\]

\[
E_T = 500 \text{ J}
\]

b. On the axes below, sketch and label graphs of the potential, kinetic, and total energies of the ball as functions of the distance fallen from the top of the cliff. [3]

c. On the axes below sketch and label the kinetic and potential energies of the ball as functions of time until the ball hits. [3]
28. Abbie and Bonita decide to race up a hill that is 30 meters high. Abbie takes a path that is 60 meters long while Bonita uses a path that is 100 meters long. It takes Abbie 40 seconds since her route is steep, while Bonita runs up her path in 30 seconds. They both start from rest at the same height and stop at the top. Abbie has a weight of 700 N while Bonita has a weight of 500 N.

(1) Is the work that Abbie does in going up the hill greater than, less than, or the same as the work that Bonita does in going up the hill?

Explain. Abbie weighs more so her gain in PE is more than Bonita. (PE = mgh) If same weight, same work.

(2) Is the power generated by Abbie in going up the hill greater than, less than, or the same as the power generated by Bonita in going up the hill?

Explain. Abbie = \( \frac{700 \text{ N}}{100 \text{ m}} \times 30 \text{ s} = 2100 \text{ J} \)

Bonita = \( \frac{500 \text{ N}}{100 \text{ m}} \times 30 \text{ s} = 1500 \text{ J} \)

29. Carts A and B are shown just before they collide. Four students discussing this situation make the following contentsions:

Alma: “After the collision, the carts will stick together and move off to the left. Cart B has more speed, and its speed is going to determine which cart dominates in the collision.”

Baxter: “I think they’ll stick together and move off to the right because Cart A is heavier. It’s like when a heavy truck hits a car: The truck is going to win no matter which one’s going fastest, just because it’s heavier.”

Callie: “I think the speed and the mass compensate, and the carts are going to be at rest after the collision.”

Dante: “The carts must have the same momentum after the collision as before the collision, and the only way this is going to happen is if they keep the same speeds. All the collision does is change their directions, so that Cart A will be moving to the left at 3 m/s and Cart B will be moving to the right at 4 m/s.”

Which, if any, of these four students do you agree with?

Alma____ Baxter____ Callie____ Dante____ None of them____

Explain. There is no indication if the carts stick together or not. Callie would be right if they stuck together. Dante would be right if it’s an elastic collision.