A. [14 pts.] A car starts up an incline at an initial speed $v_0$. The driver then slams on her brakes and skids to a stop. Use notation from lecture to represent the forces during the skid, to answer the questions below. Write none if there are no such forces. The force below are forces felt by the car.

1. **NONE** Which force(s) does/do positive work?
2. $F_W, F_r$ Which force(s) does/do negative work?
3. $F_N$ Which force(s) does/do zero work?
4. $F_r, F_N$ Which force(s) are nonconservative?
5. **NEGATIVE** The work done by the net force the car feels during the skid is (enter positive, negative or zero as the case may be)

B. [18 pts.] The picture to the right shows a wheel and axle device. A string is wrapped around each wheel (both inner and outer) and a mass is attached to each string. The two masses are identical and initially sitting on the floor at $t_0 = 0$. The wheel executes a constant angular acceleration. Both masses rise. Refer to the rim of the inner wheel as B, and the rim of the outer wheel as A. For the items below enter 1, 2, A, B, or same to best answer the questions. If the two masses have the same value, or if A and B have the same value, enter same.

1. **SAME** The wheel with the larger angular speed after 1.0 s.
2. **A** The wheel with the larger tangential speed after 1.0 s.
3. **1** The mass with the larger upward speed after 1.0 s.
4. **1** The mass feeling the greater tension during the 1.0 s interval.
5. **2** The mass rising with the smaller acceleration during the 1.0 s interval.
6. **1** The mass showing the larger increase in mechanical energy during the 1.0 s interval.
7. **B** The wheel with the smaller centripetal acceleration at $t = 1.0$ s.
8. **2** The mass on which the weight does the larger amount of negative work during the 1.0 s interval.
9. **SAME** The wheel that undergoes the larger angular displacement during the 1.0 s interval.
A stuntman of mass \( m_1 = 84.0 \, \text{kg} \) is practicing a stunt for a movie. In the stunt the stuntman starts with an initial speed of \( 4.00 \, \text{m/s} \) and slides down a circular arc (see figure). At the bottom of the slide the stuntman grabs onto a person (mass \( m_2 = 64.0 \, \text{kg} \)) who is holding a massless rope of length \( L = 10.0 \, \text{m} \) and the pair swings away from the slide. Assume the kinetic frictional force between the stuntman and slide does \( -1.50 \times 10^3 \, \text{J} \) of work.

**A.** (15 pts.) Determine the speed of the stuntman just before grabbing the person at the bottom of the slide.

\[
W_{\text{FNC}} = ME - M\vec{E}_0
\]

\[
W_{\text{FNC}} = -1.5 \times 10^3 \, \text{J}
\]

\[
-1.5 \times 10^3 = \frac{1}{2} m_1 v^2 - m_1 g h - \frac{1}{2} m v_0^2
\]

\[
v^2 = v_0^2 + 2gh - \frac{3.0 \times 10^3}{m_1}
\]

\[
v = \sqrt{(4.0 \, \text{m/s})^2 + (9.8 \, \text{m/s}^2)(6 \, \text{m}) - \frac{3 \times 10^3}{84 \, \text{kg}}}
\]

\[
v = 9.89 \, \text{m/s}
\]

**B.** (20 pts.) Determine the height \( H \) the pair reaches after the collision while holding onto the rope.

**Use Momentum Conservation To Get \( v \) After \( m_1 \) Grabs \( m_2 \)**

\[
P_{\text{TOT}}(\text{BEF}) = P_{\text{TOT}}(\text{AFT})
\]

\[
m_1 v = (m_1 + m_2) V
\]

\[
V = \frac{m_1 v}{m_1 + m_2} = \frac{(84 \, \text{kg})}{(148 \, \text{kg})} (9.89 \, \text{m/s})
\]

\[
V = 5.62 \, \text{m/s}
\]

Now **Use Energy Conservation After \( m_1 \) Grabs \( m_2 \)**

\[
W_{\text{FNC}} = 0 = ME - ME_0
\]

\[
ME = (m_1 + m_2) \frac{1}{2} g H
\]

\[
ME_0 = \frac{1}{2} (m_1 + m_2) v^2
\]

\[
h = \frac{V^2}{2g} = \frac{(5.61 \, \text{m/s})^2}{19.6 \, \text{m/s}^2}
\]

\[
h = 1.61 \, \text{m}
\]
A. Two disks with masses \( m_1 \) (2.00 kg) and \( m_2 \) (4.20 kg), are moving horizontally to the right at a speed of \( v_0 \) on an air hockey table which supports them on an essentially frictionless cushion of air. The disks move as a unit \( (v_0 = 5.00 \text{ m/s}) \) with a compressed spring between them. The spring has negligible mass. The spring is released and allowed to push the disks outward. The final velocity of \( m_1 \) is 1.20 m/s to the left.

1. [10 pts.] Find the final velocity of \( m_2 \).

\[
\begin{align*}
(\mathbf{m}_1 + \mathbf{m}_2) \mathbf{v}_0 &= \mathbf{m}_1 \mathbf{v}_1 + \mathbf{m}_2 \mathbf{v}_2 \\
(\mathbf{v}_1 - \mathbf{v}_2) &= -1.20 \text{ m/s} \\
\mathbf{v}_2 &= \frac{\mathbf{m}_2 \mathbf{v}_0 - \mathbf{m}_1 \mathbf{v}_1}{\mathbf{m}_2} \\
&= \frac{(4.20 \text{ kg})(1.20 \text{ m/s}) - (2.00 \text{ kg})(-1.20 \text{ m/s})}{4.20 \text{ kg}} \\
&= 7.95 \text{ m/s} \\

\end{align*}
\]

2. [10 pts.] Determine the impulse \( \mathbf{m}_1 \) experiences during the time the two masses separate from the spring.

\[
\mathbf{I} = \Delta \mathbf{P} = \mathbf{m}_1 \mathbf{v}_1 - \mathbf{m}_1 \mathbf{v}_0
\]

\[
= (2.00 \text{ kg})(-1.20 \text{ m/s} - 5.0 \text{ m/s})
\]

\[
\mathbf{I} = -12.4 \text{ kg m/s}
\]

B. [11 pts.] A tennis player serves a ball which arrives at the opponent’s racket traveling at a horizontal speed of 55.0 m/s. The opponent hits the ball with a forehand which sends the ball back horizontally to the server at 42.0 m/s. The ball is in contact with the strings of the racket for 1.20 ms. What is the magnitude of the average force the tennis racket exerts on the ball? The mass of the tennis ball is 0.0585 kg.

\[
\mathbf{F}_{AV} = \frac{\Delta \mathbf{P}}{\Delta t} = \frac{\mathbf{m}(\mathbf{v} - \mathbf{v}_0)}{\Delta t}
\]

\[
= \frac{(0.0585 \text{ kg})(42\text{m/s} - (-55\text{ m/s}))}{1.2 \times 10^{-3} \text{s}}
\]

\[
\mathbf{F}_{AV} = 4730 \text{ N}
\]