Given name: SOLUTIONS Family name: ____________

GTID: ____________ Signature: ____________

Georgia Institute of Technology
School of Physics

Test Form 404L

PHYS 2211 (Intro to Physics)
Instructor: Slaven Peleš

Duration: 80 minutes

Standard calculators allowed

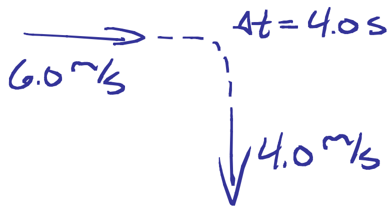
This test form consists of **6** pages and **5** questions. Please bring any discrepancy to the attention of a proctor. The number in brackets at the start of each question is the number of points the question is worth.

Answer all questions.

1. Print your name, Georgia Tech ID number, and sign the test form.
2. In each problem first define all quantities (e.g. v_{01} is initial velocity of the first object, a is the acceleration, ...) before proceeding with your calculations.
3. Show all the steps of your calculation and provide explanations when necessary. If you need more space continue working on the back of the test form sheet.
4. Explain the physical meaning of your results.

Scores will be posted on your class website. Quiz grades become final when the next test is given.

1. [25] A 2000 kgtruck traveling at a speed of 6.0 m/s makes a 90 degree turn in time of 4.0 s and emerges from this turn with a speed of 4.0 m/s. What is the magnitude of the average resultant force on the truck during this turn?



LET p REPRESENT MOMENTUM, WITH SUBSCRIPTS x & y INDICATING MOMENTUM IN THE x- & y-DIRECTIONS RESPECTIVELY. SUBSCRIPTS f & i INDICATE FINAL & INITIAL RESPECTIVELY. TIME WILL BE REPRESENTED BY t, FORCE BY F, & VELOCITY BY v.

$$F_{x\,AVG} = \frac{\Delta p_x}{\Delta t} = \frac{p_{xf} - p_{xi}}{t_f - t_i} = \frac{m(v_{xf} - v_{xi})}{t_f - t_i}$$

$$= \frac{(2000\text{ kg})(0\text{ m/s} - 6\text{ m/s})}{4.0\text{ s}} = -3000\text{ N}$$

$$F_{y\,AVG} = \frac{\Delta p_y}{\Delta t} = \frac{p_{yf} - p_{yi}}{t_f - t_i} = \frac{(2000\text{ kg})(4.0\text{ m/s} - 0\text{ m/s})}{4.0\text{ s}}$$

$$= 2000\text{ N}$$

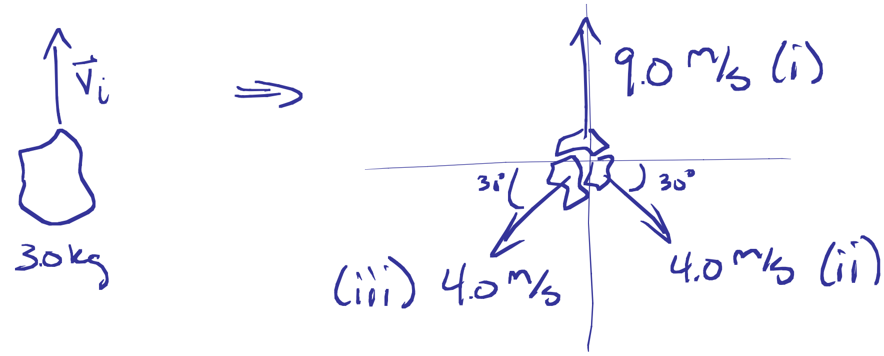
$\Rightarrow$ AVG RESULTANT FORCE $= F_{R\,AVG} = \sqrt{F_{x\,AVG}^2 + F_{y\,AVG}^2}$

$$= \sqrt{(-3000\text{ N})^2 + (2000\text{ N})^2}$$

$$= \boxed{3600\text{ N}}$$

THE AVERAGE RESULTANT FORCE $F_{R\,AVG}$ IS THE VECTOR SUM OF $\vec{F}_{x\,AVG}$ & $\vec{F}_{y\,AVG}$.

2. [25] A 3.0 kg object sliding on a frictionless horizontal surface explodes into three 1.0 kg parts. After the explosion the velocities of the three fragments are (*i*) 9.0 m/s, north; (*ii*) 4.0 m/s, 30° south of east and (*iii*) 4.0 m/s, 30° south of west. What was the magnitude of the velocity of the 3.0 kg object shortly before the explosion?



LET p REPRESENT MOMENTUM, WITH SUBSCRIPTS AS IN THE PREVIOUS PROBLEM. V & m WILL REPRESENT VELOCITY & MASS RESPECTIVELY.

$$\vec{p}_i = \vec{p}_f$$

NOTE THAT THE HORIZONTAL, OR X, COMPONENTS OF THE MOMENTA OF OBJECTS (ii) & (iii) CANCEL DUE TO THE SYMMETRY OF THE PROBLEM.

$$\Rightarrow p_{iy} = p_{fy}$$

$$\Rightarrow p_{iy} = (1.0\,\text{kg})\left[(-4.0\,\text{m/s})\sin 30° + (-4.0\,\text{m/s})\sin 30° + 9.0\,\text{m/s}\right]$$

$$= 5\ \text{N}\cdot\text{s}$$

$$\Rightarrow \vec{v}_i = \frac{\vec{p}_i}{m_i} = \frac{5\,\text{N}\cdot\text{s}\,\hat{j}}{3\,\text{kg}} = \boxed{\frac{5}{3}\ \text{m/s}\ \text{"NORTH"}}$$

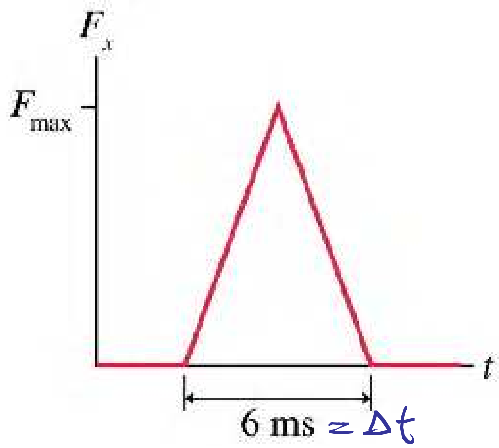
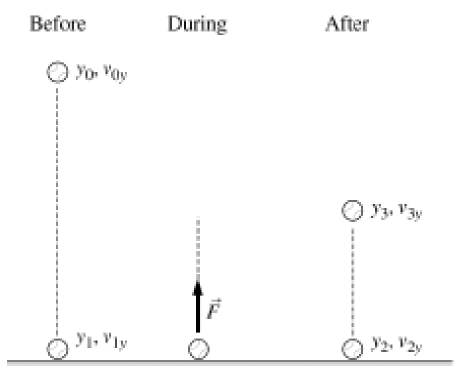


Figure 1.

3. [25] A 0.3 kg ball is dropped from a height of 1.5 m, bounces on a hardwood floor and rebounds to a height of 1.1 m. Figure 1 shows the force during the bounce. What is the maximum force the floor exerts on the ball?



Y & V REPRESENT POSITIONS & VELOCITIES AS INDICATED IN THE DIAGRAM.

$$v_f^2 = v_i^2 + 2a\Delta y \Rightarrow v_{1y}^2 = \cancel{v_{0y}^2}^{\,0} - 2g\Delta y_{10} = -2g\Delta y_{10}$$

$$\Rightarrow v_{1y} = -\sqrt{-2g\Delta y_{10}}$$

SIMILARLY, $\cancel{v_{3y}^2}^{\,0} - v_{2y}^2 = -2g\Delta y_{23} \Rightarrow v_{2y}^2 = 2g\Delta y_{23}$

$$\Rightarrow v_{2y} = \sqrt{2g\Delta y_{23}}$$

IMPULSE $= \int F(t)\,dt = \Delta p = m(v_{2y} - v_{1y})$

$$\Rightarrow \int F(t)\,dt = m\left[\sqrt{2g\Delta y_{23}} + \sqrt{-2g\Delta y_{10}}\right]$$

$$\Rightarrow \frac{1}{2} F_{MAX}\,\Delta t = m\left[\sqrt{2g\Delta y_{23}} + \sqrt{-2g\Delta y_{10}}\right]$$

$$\Rightarrow F_{MAX} = \frac{2m}{\Delta t}\left[\sqrt{2g\Delta y_{23}} + \sqrt{-2g\Delta y_{10}}\right]$$

$$= \frac{2\sqrt{2g}\,m}{\Delta t}\left(\sqrt{y_3 - y_2} + \sqrt{-(y_1 - y_0)}\right)$$

$$= \frac{2(0.3\,kg)}{(6\times 10^{-3}\,s)}\sqrt{2(9.8\,m/s^2)}\left[\sqrt{(1.1\,m - 0\,m)} + \sqrt{(1.5\,m - 0\,m)}\right]$$

$$= \boxed{1000\,N,\ \text{UPWARDS}}$$

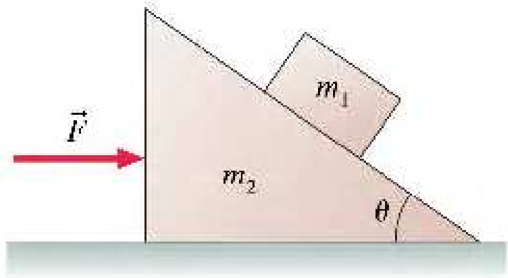
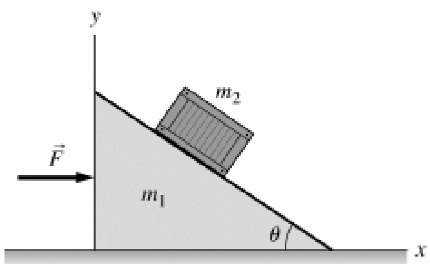


Figure 2.

4. [25] Find an expression for the magnitude of the horizontal force F in the Figure 2 for which the block with mass m_1 does not slip either up or down along the wedge. Reduce the expression to its simplest possible form. Assume all surfaces are frictionless.



$\vec{n}$ = NORMAL FORCE

a = ACCELERATION

$\vec{W}$ = WEIGHT

g = GRAVITATIONAL ACCELERATION

SUBSCRIPTS 1 & 2 REFER TO THE WEDGE & BLOCK RESPECTIVELY (NOTE THAT THIS DIFFERS FROM THE LABELS IN FIGURE 2).

The block will not slip relative to the wedge if they both have the same acceleration a.
Solve: The y-component of Newton's second law for block m_2 is

$$\sum \left(F_{\text{on }2}\right)_y = n_2 \cos\theta - w_2 = 0\text{ N} \Rightarrow n_2 = \frac{m_2 g}{\cos\theta}$$

Combining this equation with the x-component of Newton's second law yields:

$$\sum \left(F_{\text{on }2}\right)_x = n_2 \sin\theta = m_2 a \Rightarrow a = \frac{n_2 \sin\theta}{m_2} = g\tan\theta$$

Now, Newton's second law for the wedge is

$$\sum \left(F_{\text{on }1}\right)_x = F - n_2 \sin\theta = m_1 a$$

$$\Rightarrow F = m_1 a + n_2 \sin\theta = m_1 a + m_2 a = (m_1 + m_2)\, a = (m_1 + m_2)\, g \tan\theta$$

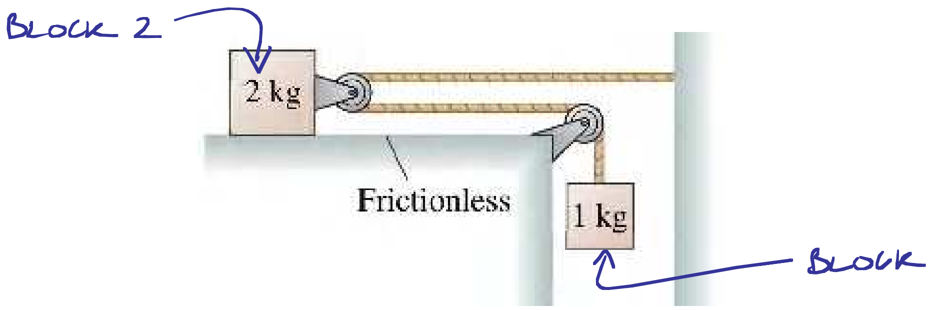


Figure 3.

5. [25] Consider motion of the system in Figure 3. Neglect the friction forces and the mass of the rope and pulleys. What is the tension in the rope? Take the gravity acceleration to be 9.8 m/s^2.

T = TENSION
a = ACCELERATION
g = GRAVITATIONAL ACCELERATION
m = MASS
W = WEIGHT

SUBSCRIPTS 1 & 2 REFER TO BLOCKS 1 & 2 RESPECTIVELY.

For every one meter that the 1-kg block goes down, each rope on the 2-kg block will be shortened by one-half meter. Thus the acceleration constraint is $a_1 = -2a_2$.

Solve: Newton's second law for the two blocks is

$$2T = m_2 a_2 \qquad T - w_1 = m_1 a_1$$

Since $a_1 = -2a_2$, the above equations become

$$2T = m_2 a_2 \qquad T - m_1 g = m_1(-2a_2)$$

$$\Rightarrow m_2 \frac{a_2}{2} + m_1(2a_2) = m_1 g \Rightarrow a_2 = \frac{2m_1 g}{m_2 + 4m_1}$$

$$\Rightarrow T = \frac{m_2 a_2}{2} = \frac{m_1 m_2 g}{m_2 + 4m_1}$$

$$= \frac{(1\,\text{kg})(2\,\text{kg})(9.8\,\text{m/s}^2)}{2\,\text{kg} + 4(1\,\text{kg})} = \boxed{3.3\,\text{N}}$$

End of examination
Total pages: 6
Total marks: 125