Phys 207 Exam #1 (3/3/05) **"Alphabetic" Student Number:** **Key #1**

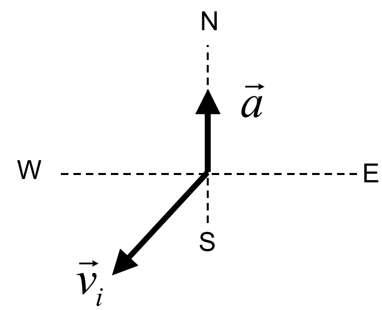
Exam AVERAGE = 79.5% (17% A, 39% B, 26% C, 11% D, 7% F)

For multiple choice answers, the correct answer is bolded. **(Ave. on all multiple choice = 62.7%)**

1. An elevator is moving **upwards** and **slowing** down. Before it stops, what statement is true about its velocity v and acceleration a? **(ave = 94%)**

   (a) $v = 0$ and $a = 0$
   (b) v points upwards and a points downwards
   (c) v and a both point upwards
   (d) v points upwards and $a = 0$
   (e) none of the above

2. Given the initial velocity and acceleration vectors for a particle shown to the right, what is the particle doing? **(ave = 58%)**



   (a) Speeding up & turning North
   (b) Speeding up & turning South
   (c) Slowing down & turning North
   (d) Slowing down & turning South
   (e) None of the above

3. If you shoot a ball upwards with an initial velocity of 25 m/s, how long does it take to go up and return to the ground? (assume g ~ 10 m/s^2) **(ave = 80%)**

   (a) 1.25 s
   (b) 2.5 s
   (c) 4 s
   (d) 5 s
   (e) none of the above.

4. A projectile is fired at 45° above the horizontal. At the highest point in its trajectory, its speed is 10 m/s. The projectile's initial velocity had a **<u>total</u> magnitude** of: **(ave = 49%)**
   (a) (10 m/s) sin 45°
   (b) (10 m/s) cos 45°
   (c) (10 m/s) tan 45°
   (d) insufficient information
   (e) **None of the above** $v = \sqrt{(10\text{ m/s})^2 + (10\text{ m/s})^2} = (10\text{ m/s})\sqrt{2}$

5. If you start accelerating from a stoplight at **2 m/s²** , **how far** will you travel before reaching a velocity of **20 m/s**? **(ave = 70%)**

   (a) **100 m** $t = \frac{20\text{ m/s}}{2\text{ m/s}^2} = 10\text{ s} \quad \Rightarrow \boxed{\Delta x = v_{ave} t} = \frac{1}{2}(0\text{ m/s} + 20\text{ m/s})(10\text{ s}) = \boxed{100\text{ m}}$

   (b) 200 m
   (c) 50 m
   (d) 40 m
   (e) None of above

6. Two metal balls of **equal mass** roll off tables of height h_1 and h_2, where $\boldsymbol{h_2 = 2\, h_1}$. The balls have the **same initial horizontal velocity** and they hit the floor at **horizontal distances** of x_1 and x_2, respectively, from the base of the table. Which statement is true? **(ave = 16%)**

   (a) x_2 (higher ball) = 0.5 x_1 (lower ball)
   (b) $x_2 = x_1$
   (c) $x_2 = 2x_1$
   (d) Insufficient information
   (e) **None of above** $x_2 = \sqrt{2}\, x_1$ because $t_2 = \sqrt{2}\, t_1$

7. In a monster-car show, a turbocharged truck is pushing a semitrailer three times its size and both are **accelerating** together at 2 m/s². The turbo truck is pushing with a force F_1 on the semitrailer, and the semitrailer is pushing back with a force F_2 on the truck. Which of the following statements is true? **(ave = 88%)**

   (a) $\boldsymbol{F_1 = F_2}$ Newton's 3rd law states that all force pairs between objects have equal magnitude.
   (b) $F_1 > F_2$
   (c) $F_1 < F_2$
   (d) $F_1 > 0, F_2 = 0$

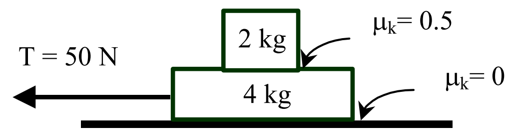
8. You horizontally push a heavy box that is sitting on a rough surface and it **does not move**. What statement is true about the magnitude of your **"pushing" force $\boldsymbol{F}$** and the magnitude of the **static friction $\boldsymbol{f}$** between the box and floor? **(ave = 38%)**

   (a) $F < f$
   (b) $F > f$
   (c) $\boldsymbol{F = f}$ If the box does not move, then the net force is zero and static friction cancels the force F.
   (d) Insufficient information.

9. A woman pushes a box of **weight** W_{1E} with a constant **horizontal force** N_{1W}. The floor is rough and has a **frictional force** f_{1S} acting on the box. If the box moves with **increasing velocity**, then which statement must be true about the magnitudes of the forces? **(ave = 89%)**

   (a) $N_{1W} = W_{1E}$
   (b) $N_{1W} > W_{1E}$
   (c) $\boldsymbol{N_{1W} > f_{1S}}$ If the box is accelerating, then the net force is positive and the woman's force is larger than the frictional force.
   (d) $N_{1W} = f_{1S}$
   (e) None of above

10. An upper 2-kg box is resting on top of a lower 4-kg box that is resting on a frictionless floor. The coefficient of kinetic friction between the two boxes is $\mu_k = 0.5$. If the **lower** box is **pulled** by a horizontal string with tension T = 50 N, what is the **acceleration** of the **upper** box? **(ave = 30%)**



   (a) $\boxed{5\ \text{m/s}^2}$ $\quad a = \frac{F}{m} = \frac{10\ \text{N}}{2\ \text{kg}} = 5\ \text{m/s}^2$ where $F = \mu N = (0.5)(20\text{N}) = 10\ \text{N}$
   (b) $10\ \text{m/s}^2$
   (c) $12.5\ \text{m/s}^2$
   (d) $15\ \text{m/s}^2$
   (e) none of the above.

11. For a block resting on a table, the 3rd law force pair for the weight of the block is: **(ave = 73%)**

   (a) the normal force
   (b) the table pushing up against the block
   (c) <u>the block pulling up on the earth</u> Remember that F_{1E} has the 3rd law pair of F_{E1}.
   (d) the block pushing down against the table
   (e) none of the above

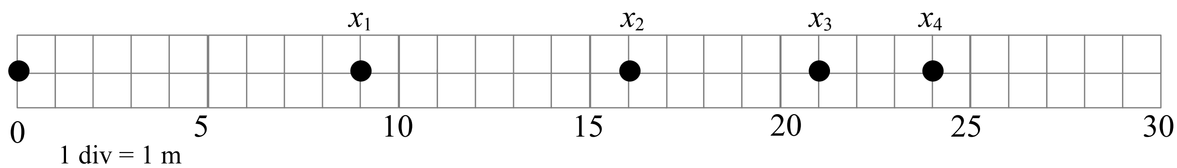
12. A force ***F*** acting on a mass m_1 results in an acceleration $\boldsymbol{a_1}$. The same force ***F*** acting on mass m_2 results in $\boldsymbol{a_2} = \boldsymbol{0.5a_1}$. What is the acceleration for the force ***F*** pushing the combination of m_1 and m_2? **(ave = 56%)**

   (a) $\boxed{\frac{1}{3}a_1}$ $\quad a_{tot} = \frac{F}{m_1 + m_2} = \frac{F}{\left(\frac{F}{a_1}\right) + \left(\frac{F}{0.5a_1}\right)} = \frac{a_1}{1+2} = \frac{a_1}{3}$
   (b) $\frac{1}{2}a_1$
   (c) $\frac{2}{3}a_1$
   (d) $\frac{3}{4}a_1$
   (e) None of the above

 "Alphabetic" Student Number: **Key #1**

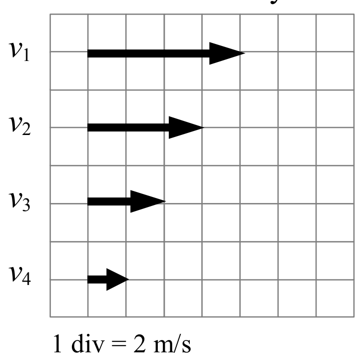
13. An object moves as indicated by the x-equation given below. Do the following: 1) draw **dots** for the object's position every second for 4 s and label them x_1 to x_4 (assume $t = 0$ s at left edge); 2) draw **velocity vectors** every second for 4 s; 3) draw a **velocity vs. time graph** for this time interval & label the y-axis; 4) draw the **acceleration vector**; and 5) write down the **velocity equation** in the indicated box and **<u>SHOW</u>** your work below the grids. **(15 pts) (ave = 84.5%)**

POSITION: $x = v_0 t + \frac{1}{2} at^2 = (10\text{ m/s})t - \frac{1}{2}(2\text{ m/s}^2)t^2$

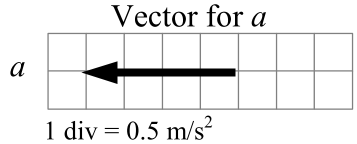


VELOCITY: $v = v_0 + at = 10\text{ m/s} - (2\text{ m/s}^2)t$

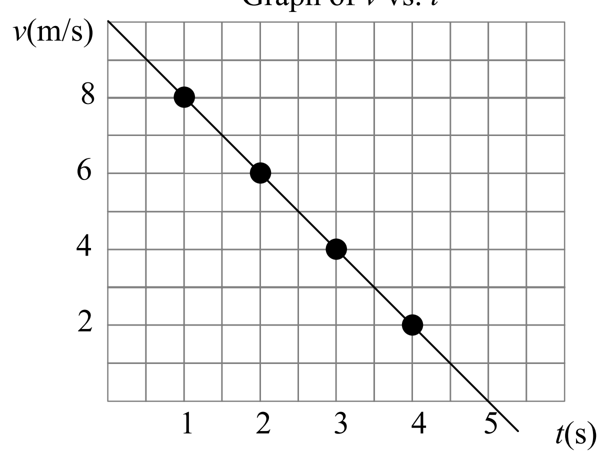
Vectors for v every second



Vector for a



Graph of v vs. t

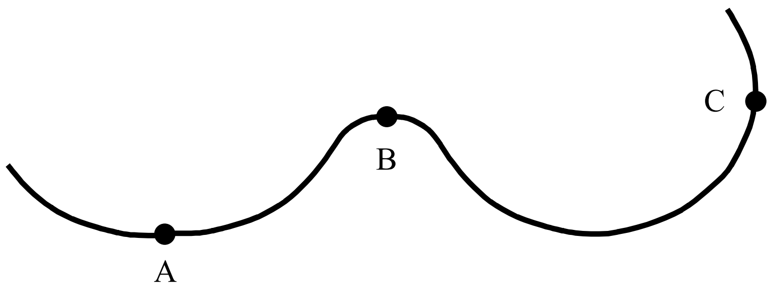


Equation for velocity: $v = 10\text{ m/s} - (2\text{ m/s}^2)\ t$

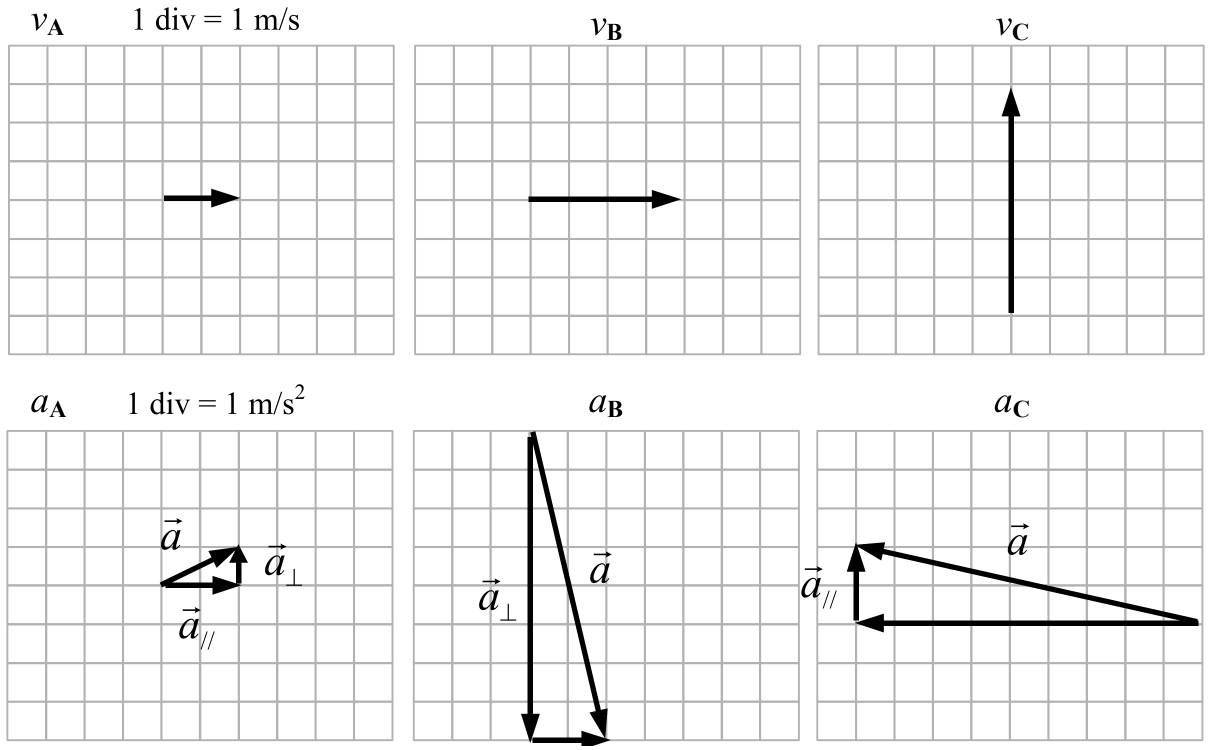
Calculations:

 "Alphabetic" Student Number: **Key #1**

14. An object moves around a curve as shown with **increasing speed**. Draw the **velocity** and **acceleration** vectors at points A, B, and C on the provided grids (to nearest integer). ***Explicitly*** draw and label the **parallel** and **perpendicular acceleration** vector components and then vectorially add them to find the total acceleration. **Show ALL** calculations at the bottom of the page. **(15 pts)** **(Ave = 88.1%)**



$\boldsymbol{v}_\mathbf{A} = 2$ m/s; $\boldsymbol{v}_\mathbf{B} = 4$ m/s; $\boldsymbol{v}_\mathbf{C} = 6$ m/s
$a = 2$ m/s^2 (**speed up**)
$\boldsymbol{r}_\mathbf{A} = 4$ m; $\boldsymbol{r}_\mathbf{B} = 2$ m; $\boldsymbol{r}_\mathbf{C} = 4$ m



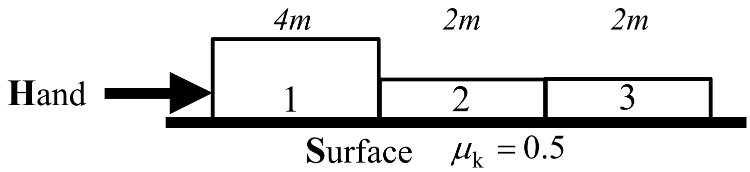
Calculations:

$$\boxed{a_{A\perp}} = \frac{v^2}{r} = \frac{(2\text{ m/s})^2}{4\text{ m}} = \boxed{1\text{ m/s}^2}$$

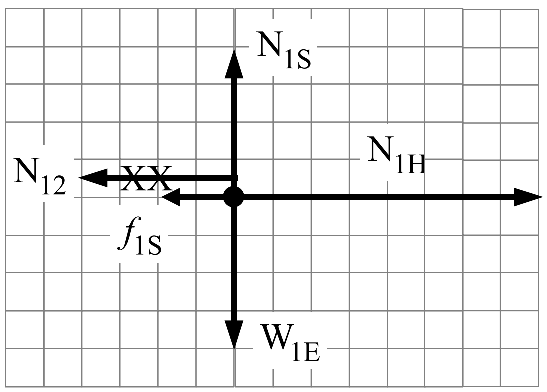
$$\boxed{a_{B\perp}} = \frac{v^2}{r} = \frac{(4\text{ m/s})^2}{2\text{ m}} = \boxed{8\text{ m/s}^2}$$

$$\boxed{a_{C\perp}} = \frac{v^2}{r} = \frac{(6\text{ m/s})^2}{4\text{ m}} = \boxed{9\text{ m/s}^2}$$

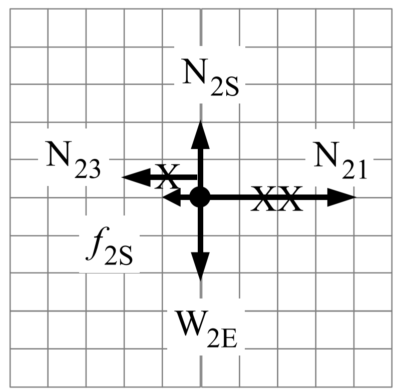
15. Three blocks are sitting on a table with kinetic coefficient of friction **μ_K= 0.5**. If a hand pushes block #1, then draw the **free body diagrams** for all blocks, draw the **net force** on each block, and mark any **3rd law force pairs** with x's or pairs of x's. Assume that the blocks have the same acceleration and that the mass of block #1 is twice that of blocks #2 and #3. **(20 pts)** **(ave = 76.9%)**



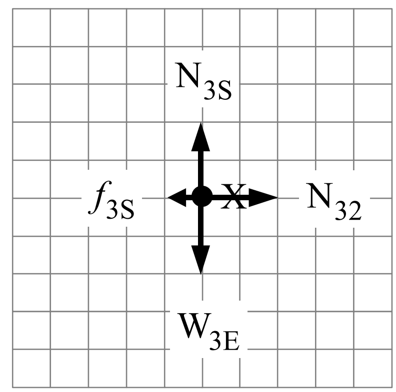
Block #1 FBD



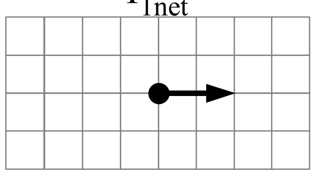
Block #2 FBD



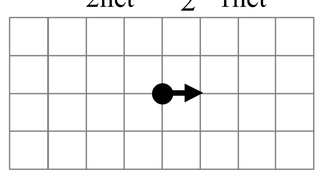
Block #3 FBD



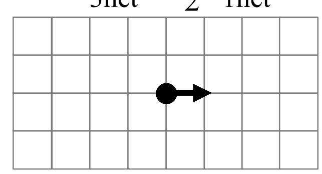
F_{1net}



$F_{2net} = \frac{1}{2} F_{1net}$

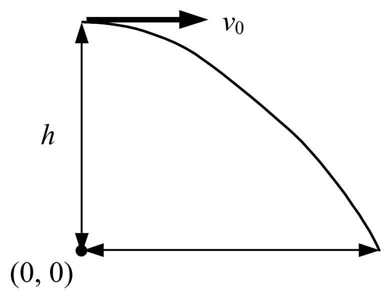


$F_{3net} = \frac{1}{2} F_{1net}$



16. A cannonball is shot with horizontal velocity of 20 m/s from the roof of a building (initial vertical velocity is zero). Assume that the building has height h (= 125 m) and use a coordinate system with the origin located on the ground directly below where the cannoball is shot. **(20 pts) (Ave = 86.5%)**

(a) Draw a **diagram** of the problem that shows the **path** of the cannonball, the initial **velocity vector**, the **origin** with a dot and labeled (0,0), the **height** h of the building, and the **known variables** as indicated.



x_0 = 0 m

y_0 = 125 m

v_{x0} = 20 m/s

v_{y0} = 0 m/s

(b) Find the **time t** that the cannonball is in the air before hitting the ground. **Show all steps** in your work starting from the equations of motion and assume g = 10 m/s^2.

$$y = y_0 + v_{y0}t - \tfrac{1}{2}gt^2$$

$$0 = 125\text{ m} + 0 - \tfrac{1}{2}\left(10\text{ m/s}^2\right)t^2$$

$$t = \sqrt{\frac{125\text{ m}}{5\text{ m/s}^2}} = \boxed{5\text{ s}}$$

(c) Find the **range *x*** traveled by the cannonball. **Show all steps** in your work.

$$x = x_0 + v_{x0}t$$

$$x = 0 + (20\text{ m/s})(5\text{ s}) = \boxed{100\text{ m}}$$

(d) If the height of the building is **doubled** to 250 m, by what **factor** does the time t increase?

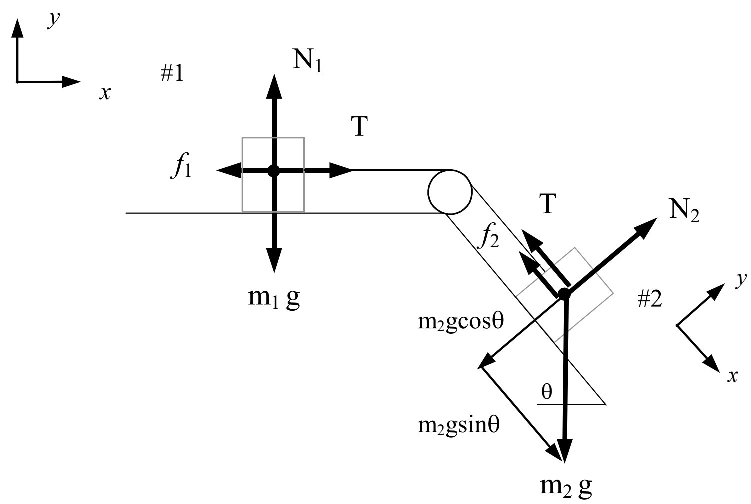
From part (b), $y = y_0 - \tfrac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2(y_0 - y)}{g}} = \sqrt{\frac{2h}{g}}$

Therefore, $\frac{t_2}{t_1} \propto \sqrt{\frac{h_2}{h_1}} = \sqrt{\frac{2h}{h}} = \boxed{\sqrt{2}}$

The time is $\sqrt{2}$ **larger**, or ~40% longer for falling twice the distance.

17. Two blocks of mass m_1 and m_2 are connected by a massless rope as shown below. Block #1 is on a horizontal surface with kinetic **coefficient of friction** μ_k and block #2 is on an incline with angle θ and the same coefficient of friction. The rope slides without friction on the pulley between them. Use the **standard orientation** for axes as provided in the homework solutions. **(30 pts total) (ave = 87.5%)**

(a) Draw the **free-body diagrams** for blocks #1 and #2 **ON the blocks** using the center dots. Label ALL vectors, draw the *x-y* axes for each block, and include any necessary *x-y* component vectors. For consistency, label weights using ***mg*** terms, normal forces using ***N*** terms, friction using ***f*** terms, and the tension between blocks #1 and #2 as ***T***.



(b) Write down the $\sum F_y = ma_y$ and $\sum F_x = ma_x$ equations for blocks #1 and #2. Explicitly **substitute** for **frictional** forces f (= $\mu_k N$) using given constants and variables (μ_k, m, θ, g).

Block #1

$$\sum F_{1y} = \boxed{N_1 - m_1 g = 0}$$

$$\sum F_{1x} = T - f_1 = m_1 a \quad \text{where } f_1 = \mu_k N_1 = \mu_k m_1 g$$

$$\boxed{T - \mu_k m_1 g = m_1 a} \quad \text{Eqn. \#1}$$

Block #2

$$\sum F_{2y} = \boxed{N_2 - m_2 g \cos\theta = 0}$$

$$\sum F_{2x} = m_2 g \sin\theta - T - f_2 = m_2 a \quad \text{where } f_2 = \mu_k N_1 = \mu_k m_2 g \cos\theta$$

$$\boxed{m_2 g \sin\theta - T - \mu_k m_2 g \cos\theta = m_2 a} \quad \text{Eqn. \#2}$$

(c) Use the force equations to find an **algebraic** expression for the **acceleration** ***a*** of the blocks.

>> Add Eqns. #1 and #2 from part (b) and solve for *a*.

$$\left(T - \mu_k m_1 g\right) + \left(m_2 g \sin\theta - T - \mu_k m_2 g \cos\theta\right) = m_1 a + m_2 a$$

$$\boxed{a = \frac{m_2 g \sin\theta - \mu_k m_1 g - \mu_k m_2 g \cos\theta}{m_1 + m_2}}$$