Nagy,

Tibor

Keep this exam **CLOSED** until advised by the instructor.
50 minute long closed book exam.
Fill out the bubble sheet: last name, first initial, **student number**. Leave the section, code and form areas empty.
A two-sided handwritten 8.5 by 11 help sheet is allowed.
When done, hand in your **test** and your **bubble sheet**.
Thank you and good luck!

Posssibly useful constant:

- $g = 9.81\ m/s^2$

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Please, sit in row O.

1 pt Are you sitting in the seat assigned?

1.A ◯ Yes, I am.

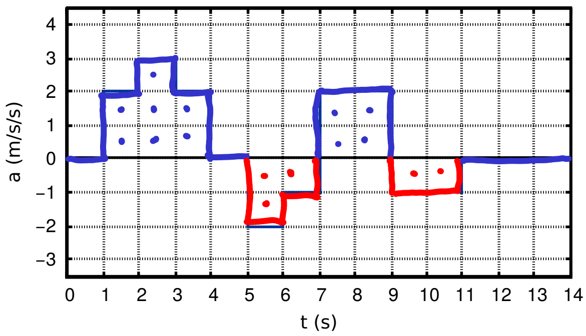
3 pt A pen, a pineapple and an apple are all dropped from the second floor of a building at the same time. Which object(s) will hit the ground first? Important: the pen is not a goose feather pen, but a heavy ball pen with steel casing.

2.A◯ The pen and the pineapple will hit the ground first in a tie.
B◯ The apple will hit first.
C◯ They all hit the ground at the same time.
D◯ Without knowing the masses of the objects, we cannot tell which one hits the ground first.
E◯ The pen will hit first.
F◯ The pineapple and the apple will hit the ground first in a tie.
G◯ The pineapple will hit first.
H◯ The apple and the pen will hit the ground first in a tie.

All objects (compact and dense objects) fall together, when they are released at the same time from the same height.

Galileo Galilei

A car is initially at rest on a straight road. The graph shows the acceleration of the car along that road as a function of time.



$\boxed{4\ pt}$ What is the speed of the car at t=14 s?
(in m/s*)*

3. **A**◯ 1.0 **B**◯ 2.0 **C**◯ 3.0 **D**◯ 5.0 **E**◯ 6.0 **F**◯ 8.0 **G**◯ 9.0 **H**◯ 10.0

Definition of acceleration: $a = \frac{\Delta v}{\Delta t}$

Change in velocity: $\Delta v = \underbrace{a \cdot \Delta t}_{\text{area}}$

The area under the a vs. t graph is the change in velocity. The area above the time axis is positive, the area under is negative. The initial velocity is zero m/s, the car starts from rest.

$v = \underbrace{0}_{v_0} + 7 - 3 + 4 - 2 = 6\,m/s.$

4 pt A small, single engine airplane is about to take off. The airplane becomes airborne, when its speed reaches 111.0 km/h. The conditions at the airport are ideal, there is no wind. When the engine is running at its full power, the acceleration of the airplane is 2.10 m/s^2. What is the minimum required length of the runway?
(in m*)*

4. **A**◯ 7.42×10^1 **B**◯ 1.08×10^2 **C**◯ 1.56×10^2 **D**◯ 2.26×10^2
E◯ 3.28×10^2 **F**◯ 4.76×10^2 **G**◯ 6.90×10^2 **H**◯ 1.00×10^3

$$v^2 = 2ad \Rightarrow d_{min} = \frac{v^2}{2a}$$

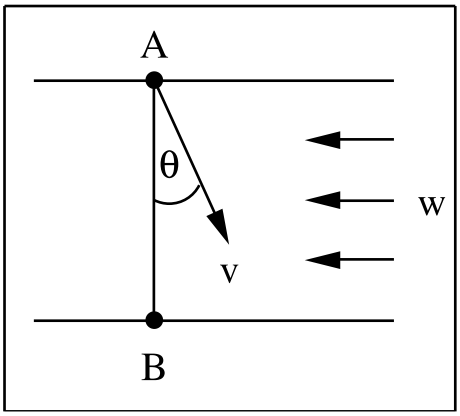
Important: $3.6\ \frac{km}{h} = 1\ \frac{m}{s}$

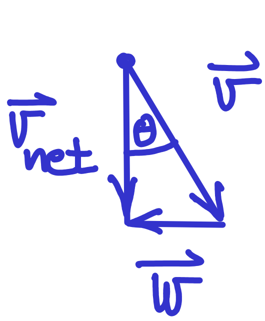
$$v = 111\ \frac{km}{h} = 30.83\ \frac{m}{s}$$

$$a = 2.10\ \frac{m}{s^2}$$

Therefore: $d_{min} = \frac{v^2}{2a} = 226\,m.$

You are planning to cross a river by a motor boat from point A to B. Points A and B are located exactly opposite from each-other. (See figure.)





$\vec{v}_{net} = \vec{v} + \vec{w}$

The speed of the boat is v = 3.00 m/s in still water. The river flows with a speed of w = 1.95 m/s.

$\boxed{3\ pt}$ At which angle θ should you aim your boat to go from A to B?
(in deg*)*

5. **A**◯ 16.6 **B**◯ 20.8 **C**◯ 25.9 **D**◯ 32.4 **E**◯ 40.5 **F**◯ 50.7 **G**◯ 63.3 **H**◯ 79.2

$\boxed{3\ pt}$ If the width of the river is 85.3 m, then how much time will it take for you to cross the river?
(in s*)*

6. **A**◯ 17.8 **B**◯ 25.8 **C**◯ 37.4 **D**◯ 54.3
E◯ 78.7 **F**◯ 114.1 **G**◯ 165.4 **H**◯ 239.9

$\sin\theta = \frac{w}{v} \Rightarrow \theta = \sin^{-1}\left(\frac{1.95}{3}\right) = 40.5^\circ$

Pythagorean theorem: $v^2 = w^2 + v_{net}^2$

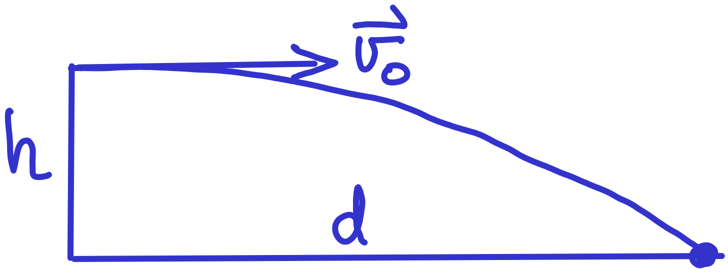
$\Rightarrow v_{net} = \sqrt{v^2 - w^2} = \sqrt{3^2 - 1.95^2} = 2.28\,\frac{m}{s}$

Crossing time: $t = \frac{d}{v_{net}} = \frac{85.3\,m}{2.28\,\frac{m}{s}}$

$t = 37.4\,s$

$\boxed{4\ pt}$ A baseball is projected horizontally with an initial speed of 24.7 m/s from a height of 1.95 m. At what horizontal distance will the ball hit the ground? (Neglect air friction.)
(in m)

7. **A**◯ 8.80 **B**◯ 1.17×10^1 **C**◯ 1.56×10^1 **D**◯ 2.07×10^1
E◯ 2.75×10^1 **F**◯ 3.66×10^1 **G**◯ 4.87×10^1 **H**◯ 6.48×10^1



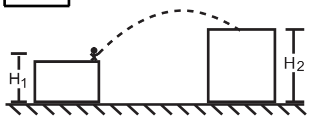
Free fall: $h = \frac{1}{2} g t^2 \Rightarrow$ time of fall from height h: $t = \sqrt{\frac{2h}{g}}$

$$t = \sqrt{\frac{2 \cdot 1.95}{9.81}} = 0.63\,s$$

Horizontal distance: $d = v_0 \cdot t$

$$d = 24.7 \cdot 0.63 = 15.6\,m$$

$\boxed{\textit{4 pt}}$ A boy standing on top of a building throws a small ball from a height of $H_1 = 22.7$ m. (See figure.)



The ball leaves with a speed of 27.3 m/s, at an angle of 78.0° to the horizontal, and lands on a building with a height $H_2 = 32.8$ m. Neglect air friction, and calculate for how long the ball is in the air.
(in s*)*

8. **A**◯ 4.03 **B**◯ 5.04 **C**◯ 6.29 **D**◯ 7.87
E◯ 9.83 **F**◯ 1.23×10^1 **G**◯ 1.54×10^1 **H**◯ 1.92×10^1

$$y(t) = H_1 + (v_0 \cdot \sin\Theta)t - \frac{1}{2}gt^2$$

Landing on building H_2 at time t^*:

$$H_2 = H_1 + (v_0 \cdot \sin\Theta)t^* - \frac{1}{2}g t^{*2}$$

$$\frac{1}{2}gt^{*2} - (v_0 \cdot \sin\Theta)t^* + (H_2 - H_1) = 0$$

$$t^*_{1,2} = \frac{(v_0 \cdot \sin\Theta) \pm \sqrt{(v_0 \sin\Theta)^2 - 4\frac{1}{2}g(H_2 - H_1)}}{g}$$

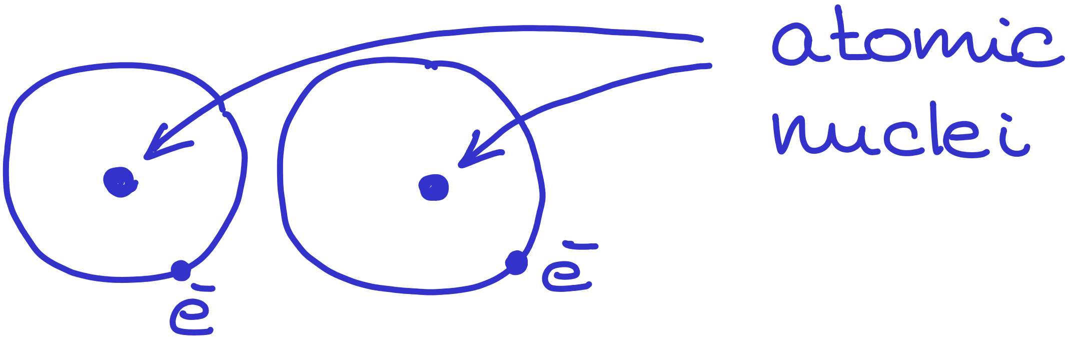
$$(v_0 \cdot \sin\Theta) = 26.7 \frac{m}{s}; \quad 2g(H_2 - H_1) = 198.2 \frac{m^2}{s^2}$$

$$t^*_{1,2} = \frac{26.7 \pm 22.7}{9.81} = \begin{cases} \underline{5.04\,s} \\ 0.41\,s \end{cases}$$

$\boxed{\textit{4 pt}}$ At the fundamental, microscopic level which of the following forces are electromagnetic in nature?

9.A◯ normal force
B◯ static friction
C◯ kinetic friction
D◯ air drag
E◯ buoyant force
F◯ all the forces on this list
G◯ none of the forces on this list
H◯ tension force

The normal force, tension, static friction, kinetic friction, air drag, buoyant forces are all contact forces. Contact forces are results of the interactions between electrons:



$\boxed{4\ pt}$ Two forces $\mathbf{F_1}$ = -5.40**i** + 3.90**j** and $\mathbf{F_2}$ = 6.10**i** + 4.50**j** are acting on a mass of m = 4.30 kg. The forces are measured in newtons. What is the magnitude of the object's acceleration?
(in `m/s^2`*)*

10. **A**◯ 8.33×10^{-1} **B**◯ 9.42×10^{-1} **C**◯ 1.06 **D**◯ 1.20
E◯ 1.36 **F**◯ 1.54 **G**◯ 1.73 **H**◯ 1.96

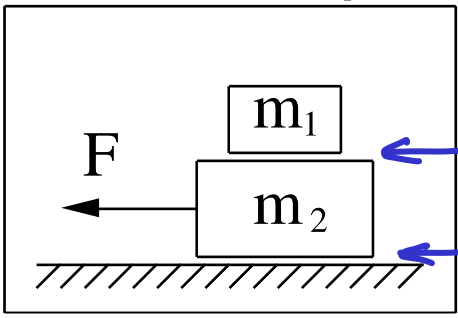
$$\left.\begin{aligned} \vec{F}_1 &: -5.40\hat{i} + 3.90\hat{j} \\ \vec{F}_2 &: \ \ \ 6.10\hat{i} + 4.50\hat{j} \\ \hline \vec{F}_{net} &: \ \ \ 0.70\hat{i} + 8.40\hat{j} \end{aligned}\right\}$$ vector addition

$$F_{net} = |\vec{F}_{net}| = \sqrt{0.70^2 + 8.40^2} = 8.43\,N$$

Newton's second law: $F_{net} = ma \Rightarrow$

$$\Rightarrow a = \frac{F_{net}}{m} = \frac{8.43\,N}{4.30\,kg} = 1.96\,\frac{m}{s^2}$$

Two blocks with masses of $m_1 = 1.11$ kg and $m_2 = 3.10$ kg are stacked on top of each other as shown in the figure.



Yes friction: $\mu_s = 0.453$

No friction.

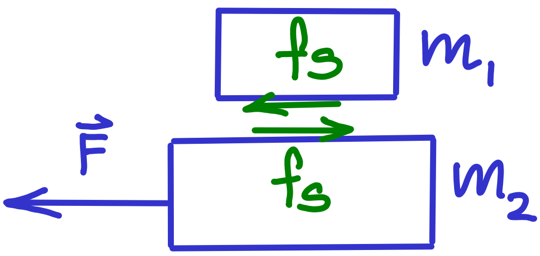
The coefficient of static friction between the two blocks is $\mu_s = 0.453$. The friction between the bottom block and the horizontal surface is negligible.

$\boxed{\textit{3 pt}}$ What is the largest horizontal force F that can be applied to the bottom block so that the two blocks will not slide relative to each other?
(in N*)*

11. **A**◯ 6.23 **B**◯ 7.29 **C**◯ 8.53 **D**◯ 9.98
E◯ 11.68 **F**◯ 13.67 **G**◯ 15.99 **H**◯ 18.71

$\boxed{\textit{3 pt}}$ What is the acceleration of the system, when this largest force is applied?
(in m/s^2*)*

12. **A**◯ 1.46 **B**◯ 1.82 **C**◯ 2.28 **D**◯ 2.84 **E**◯ 3.56 **F**◯ 4.44 **G**◯ 5.55 **H**◯ 6.94



The static friction is at its maximum value:

$$f_s = \mu_s N = \mu_s m_1 g$$

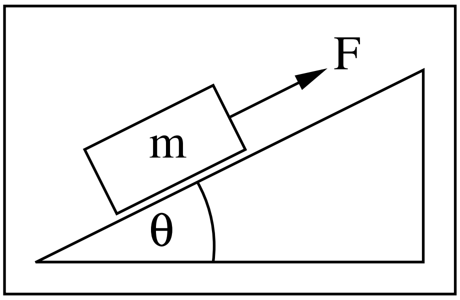
giving m_1 the maximum acceleration:

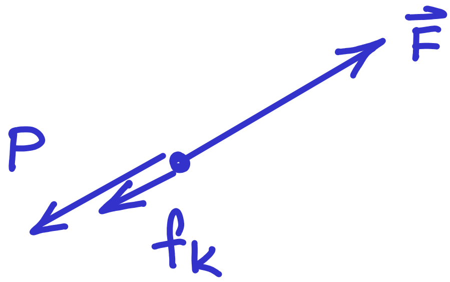
$$a_{max} = \frac{f_s}{m_1} = \frac{\mu_s m_1 g}{m_1} = \mu_s g = 4.44 \frac{m}{s^2}$$

The two objects accelerate together with this acceleration:

$$F = (m_1 + m_2) \cdot a_{max} = (m_1 + m_2) \mu_s g = 18.7 \text{ N}$$

4 pt A force **F**, with a magnitude of 21.2 N, acts on an object with a mass of m = 1.25 kg parallel to the plane of the incline as shown in the figure.





The angle of the incline is $\theta = 39.7°$. The object is observed to move at a constant velocity of 2.13 m/s up on the incline. Calculate the magnitude of the frictional force acting on the object.
(in N*)*

13. **A**◯ 8.20 **B**◯ 9.26 **C**◯ 1.05×10^1 **D**◯ 1.18×10^1
E◯ 1.34×10^1 **F**◯ 1.51×10^1 **G**◯ 1.71×10^1 **H**◯ 1.93×10^1

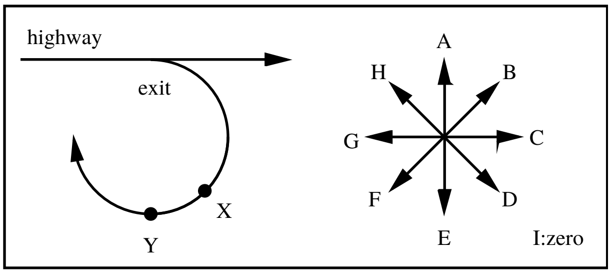
If the velocity is constant, then the acceleration is zero. If the accel. is zero, then the net force is zero.

Therefore: $F = P + f_k \Rightarrow f_k = F - P$

$f_k = F - mg\sin(\theta) = 21.2 - 1.25 \cdot 9.81 \cdot \sin(39.7°)$

$f_k = 13.4\,N$

A car is exiting the highway on a circular exit ramp. (See figure.)



$\boxed{3\ pt}$ The driver slows the car down to the posted speed limit, enters the exit ramp and then maintains a constant speed. When the car is at point **X** on the ramp, which vector best represents the direction of the car's acceleration?

14.A◯ A.
B◯ B.
C◯ C.
D◯ D.
E◯ E.
F◯ F.
G◯ G.
H◯ H.
I◯ I: the acceleration is zero.

At X the car accelerates toward the center : a_{cp} only because the speed is constant.

$\boxed{3\ pt}$ After passing point **X** but before reaching point **Y** the driver starts to push the brake pedal and applies the brakes for the rest of the exit ramp. Which vector best represents the direction of the car's acceleration when the car is at point **Y**?

15.A◯ A.
B◯ B.
C◯ C.
D◯ D.
E◯ E.
F◯ F.
G◯ G.
H◯ H.
I◯ I: the acceleration is zero.

At Y the car accelerates toward the center and backwards at the same time. a_{cp} : A ; a_t : C ;
a_{net} : B.