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 C.

1 pt Are you sitting in the seat assigned?

1.A◯ Yes, I am.

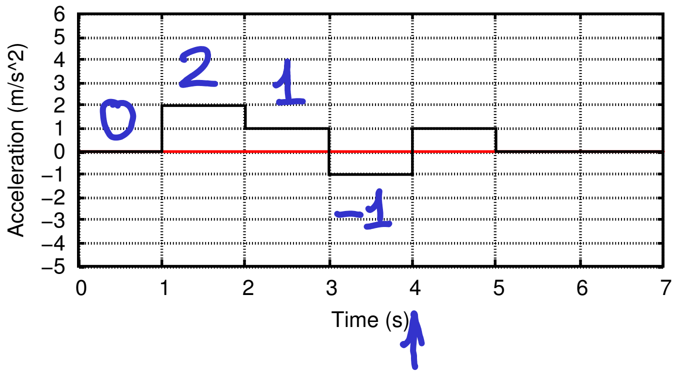
$\boxed{3\ pt}$ An apple, a brick and a hammer are all dropped from the second floor of a building. Which object(s) will hit the ground first?

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

All compact and dense objects (not feathers or leaves) fall together.

Galileo Galilei

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



$$a = \frac{\Delta v}{\Delta t} \Rightarrow$$

$$\Rightarrow \Delta v = a \cdot \Delta t$$

$\boxed{\textit{3 pt}}$ Calculate the speed of the car at $t = 4$ s.
(in `m/s`*)*

3. **A**◯ 2 **B**◯ 3 **C**◯ 4 **D**◯ 5 **E**◯ 6 **F**◯ 7 **G**◯ 8 **H**◯ 9

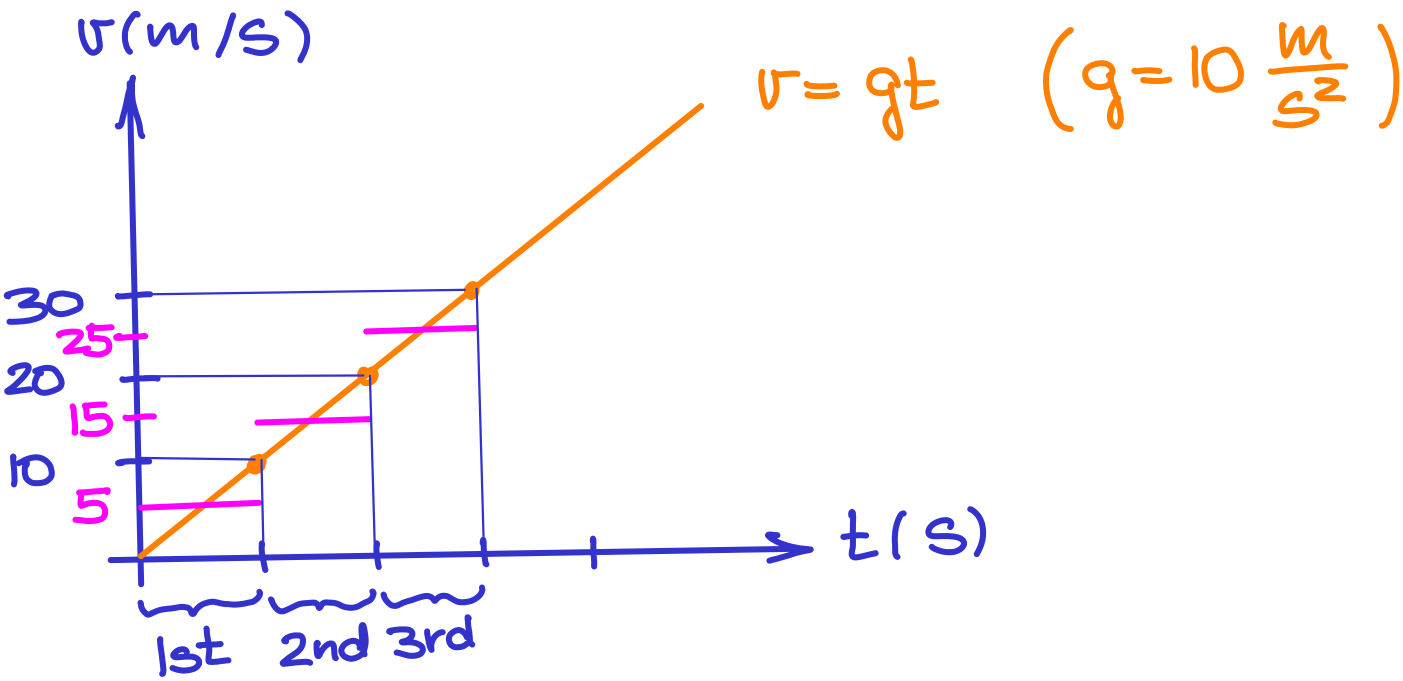
$$v = v_0 + a \cdot \Delta t \quad ; \quad \Delta t = 1\,\text{s}$$

$$v = 0 + 0 + 2 + 1 - 1 = 2\ \text{m/s}$$

3 pt A large rock is released from rest from the top of a tall building. The average speed of the rock during the first second of the fall is 5 m/s. What is the average speed of the rock during the third second?

→ implies $g = 10\,m/s^2$

4.A◯ 5 m/s
B◯ 15 m/s
C◯ 50 m/s
D◯ 0 m/s
E◯ 20 m/s
F◯ 100 m/s
G◯ 25 m/s
H◯ 10 m/s
I◯ 30 m/s



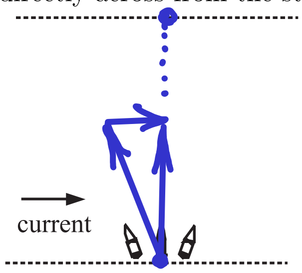
Galileo's pattern:

5, 15, 25, 35, 45 ...

in the relative ratios of the consequtive odd numbers:

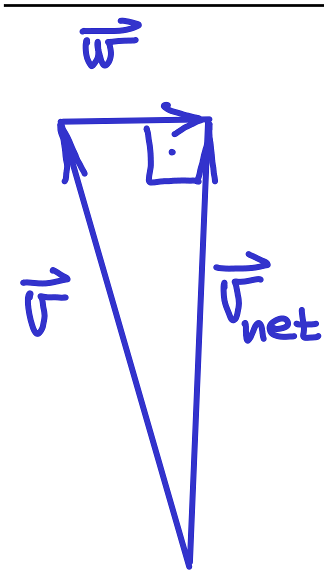
1, 3, 5, 7, 9, ...

$\boxed{\textit{4 pt}}$ A boat crossing a 277.0 m wide river is directed so that it will cross the river and land on the opposite shore directly across from the starting point.



The boat has a speed of 5.20 m/s in still water and the river flows uniformly at 3.70 m/s. Calculate the time required for the boat to reach the opposite shore.
(in s*)*

5. **A**◯ 1.59×10^1 **B**◯ 1.99×10^1 **C**◯ 2.48×10^1 **D**◯ 3.11×10^1
E◯ 3.88×10^1 **F**◯ 4.85×10^1 **G**◯ 6.06×10^1 **H**◯ 7.58×10^1



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

Pithagoras:

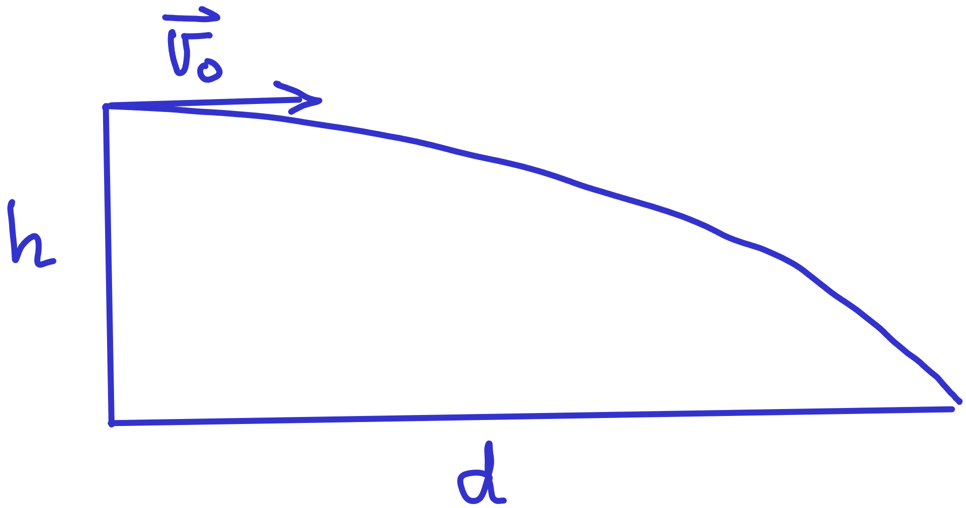
$v^2 = w^2 + v_{net}^2$

$\sqrt{v^2 - w^2} = v_{net}$

$t = \dfrac{d}{v_{net}}$

$\boxed{4\ pt}$ A baseball is projected horizontally with an initial speed of 20.5 m/s from a height of 1.51 m. At what horizontal distance will the ball hit the ground? (Neglect air friction.)
(in m*)*

6. **A**◯ 1.14×10^1 **B**◯ 1.33×10^1 **C**◯ 1.56×10^1 **D**◯ 1.82×10^1
E◯ 2.13×10^1 **F**◯ 2.49×10^1 **G**◯ 2.92×10^1 **H**◯ 3.41×10^1



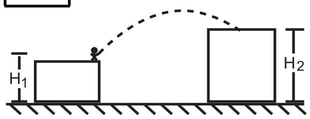
Time of fall from height h:

$$h = \frac{1}{2} g t^2 \Rightarrow \sqrt{\frac{2h}{g}} = t$$

Distance travelled horizontally:

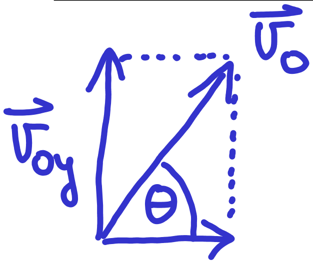
$$d = v \cdot t = v\sqrt{\frac{2h}{g}}$$

$\boxed{4\ pt}$ A boy standing on top of a building throws a small ball from a height of $H_1 = 21.0$ m. (See figure.)



The ball leaves with a speed of 26.8 m/s, at an angle of 75.0° to the horizontal, and lands on a building with a height $H_2 = 36.6$ m. Neglect air friction, and calculate for how long the ball is in the air.
(in s*)*

7. **A**◯ 1.50 **B**◯ 1.88 **C**◯ 2.35 **D**◯ 2.93 **E**◯ 3.67 **F**◯ 4.58 **G**◯ 5.73 **H**◯ 7.16



$$v_{0y} = v_0 \cdot \sin\theta$$

$$y(t) = H_1 + v_{0y} \cdot t - \frac{1}{2} g t^2$$

at $t = t^*$: $y(t) = H_2$

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

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

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

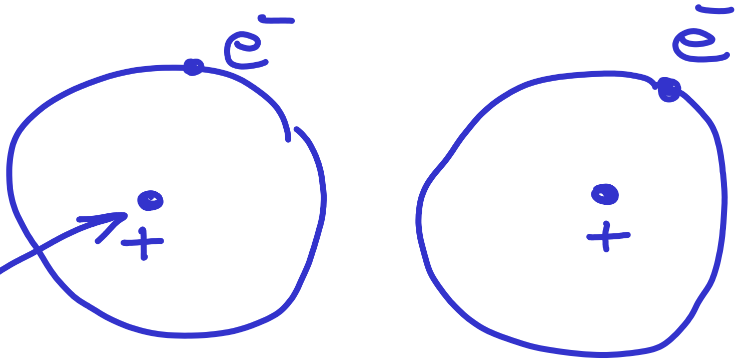
$$t^*_{1,2} = \frac{v_0 \cdot \sin\theta \pm \sqrt{(v_0 \cdot \sin\theta)^2 - 2g (H_2 - H_1)}}{g}$$

You will get two positive roots.
You will need the larger one.

3 pt At the fundamental, microscopic level which of the following forces are electromagnetic in nature?

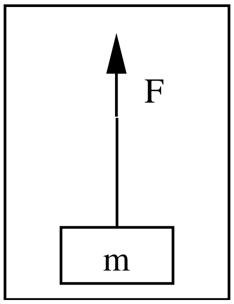
8.A◯ tension force
B◯ buoyant force
C◯ all the forces on this list
D◯ static friction
E◯ kinetic friction
F◯ air drag
G◯ none of the forces on this list
H◯ normal force

All contact forces in everyday life are the results of electromagnetic interactions between electrons.



nucleus: positive protons and neutral neutrons are here.

An m = 7.25 kg mass is suspended on a string which is pulled upward by a force of F = 76.5 N as shown in the figure.



$\boxed{\textit{4 pt}}$ If the upward velocity of the mass is 2.25 m/s right now, then what is the velocity 5.50 s later? *(in* `m/s`*)*

9.

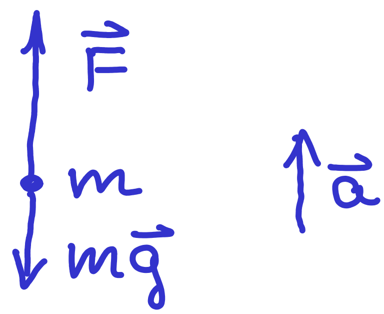
A◯ 6.35	**B**◯ 7.17	**C**◯ 8.10	**D**◯ 9.16
E◯ 1.03×10^1	**F**◯ 1.17×10^1	**G**◯ 1.32×10^1	**H**◯ 1.49×10^1

$$F_{net} = ma$$

$$F - mg = ma$$

$$\frac{F - mg}{m} = a$$

$$v = v_0 + at$$

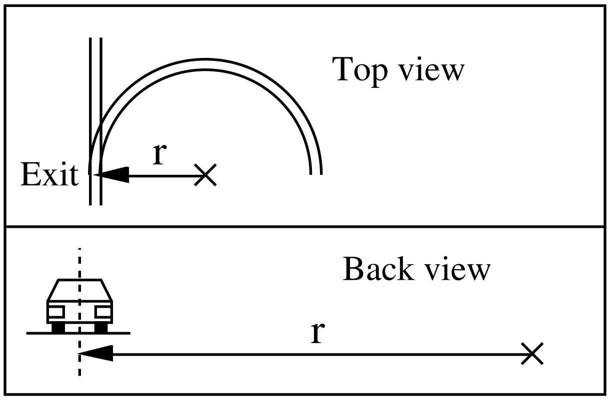


$\boxed{\textit{3 pt}}$ Two forces $\mathbf{F_1}$ = -8.30**i** + 5.50**j** and $\mathbf{F_2}$ = 6.30**i** + 7.60**j** are acting on a mass of m = 6.50 kg. The forces are measured in newtons. What is the magnitude of the object's acceleration?
(in `m/s^2`*)*

10. **A**◯ 6.52×10^{-1} **B**◯ 8.67×10^{-1} **C**◯ 1.15 **D**◯ 1.53
E◯ 2.04 **F**◯ 2.71 **G**◯ 3.61 **H**◯ 4.80

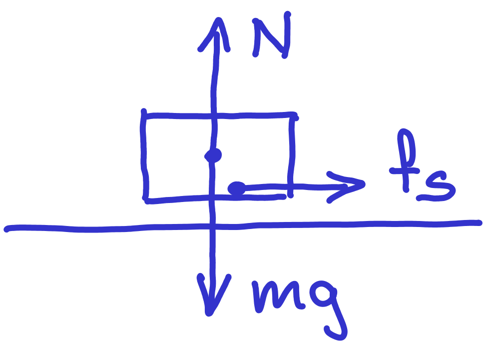
$$\vec{F}_1 = -8.3i + 5.5j$$
$$\vec{F}_2 = 6.3i + 7.6j$$
$$\vec{F}_{net} = -2.0i + 13.1j$$
$$F_{net} = |\vec{F}_{net}| = \sqrt{(-2.0)^2 + 13.1^2}$$
$$a = \frac{F_{net}}{m}$$

The radius of curvature of a highway exit is r = 82.5 m. The surface of the exit road is horizontal, not banked. (See figure.)



$\boxed{4\ pt}$ What is the minimum required value of the coefficient of static friction between the surface of the road and the tires so that the car can exit the highway safely without sliding at a constant speed of 53.8 km/h?

11. **A**◯ 1.47×10^{-1} **B**◯ 1.72×10^{-1} **C**◯ 2.02×10^{-1} **D**◯ 2.36×10^{-1}
E◯ 2.76×10^{-1} **F**◯ 3.23×10^{-1} **G**◯ 3.78×10^{-1} **H**◯ 4.42×10^{-1}



The static friction f_s keeps the car on a circular path:

$$f_s = m a_{cp}$$

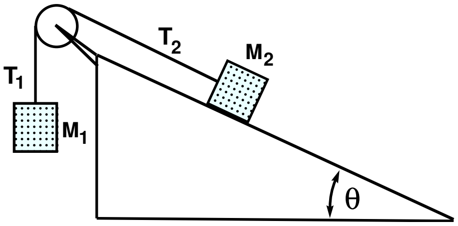
$$\mu_s N = m \frac{v^2}{r}$$

$$\mu_s mg = m \frac{v^2}{r}$$

$$\mu_s = \frac{v^2}{gr}$$

(3.6 km/h = 1 m/s)

$\boxed{10\ pt}$ M_1 and M_2 have equal masses and are connected as shown. T_1 and T_2 are the tensions in the rope. The pulley is frictionless and massless. The incline is frictionless and is at an angle of $\theta = 30.0°$ from the horizontal. The quantities T_1, T_2 and g are magnitudes.



▷ The magnitude of the acceleration of M_1 is .... that of M_2
12. **A**◯ greater than **B**◯ less than **C**◯ equal to

▷ T_2 is .... M_2 g sin(θ)
13. **A**◯ greater than **B**◯ less than **C**◯ equal to

▷ T_1 is .... M_2g
14. **A**◯ greater than **B**◯ less than **C**◯ equal to

▷ T_1 is .... T_2
15. **A**◯ greater than **B**◯ less than **C**◯ equal to

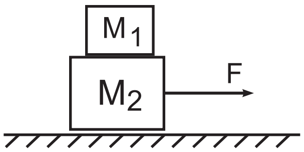
▷ T_1 is .... M_1g
16. **A**◯ greater than **B**◯ less than **C**◯ equal to

The system accelerates with M_1 down and M_2 uphill, because $M_1 = M_2$ and M_2 is on a frictionless incline.

$a_1 = a_2$ (and $v_1 = v_2$ and $\Delta x_1 = \Delta x_2$) because the rope doesn't stretch.

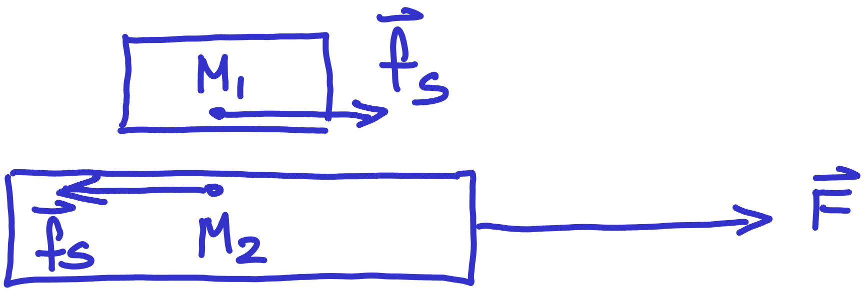
$$M_1 g > \underbrace{T_1 = T_2}_{\text{because the pulley is ideal}} > M_2 g \cdot \sin\theta$$

4 pt Two masses $M_1 = 2.00$ kg and $M_2 = 8.70$ kg are stacked on top of each other as shown in the figure. The static coefficient of friction between M_1 and M_2 is $\mu_s = 0.220$. There is no friction between M_2 and the surface below it.



What is the maximum horizontal force that can be applied to M_2 without M_1 sliding relative to M_2?
(in N*)*

17. **A** ◯ 5.55 **B** ◯ 7.38 **C** ◯ 9.82 **D** ◯ 1.31×10^1
E ◯ 1.74×10^1 **F** ◯ 2.31×10^1 **G** ◯ 3.07×10^1 **H** ◯ 4.08×10^1



M_1 : $\quad f_s = M_1 \cdot a$

$$\mu_s M_1 g = M_1 a$$

$$\mu_s g = a$$

$(M_1 + M_2)$: $\quad F = (M_1 + M_2)\, a$

$$F = (M_1 + M_2)\, \mu_s g$$