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

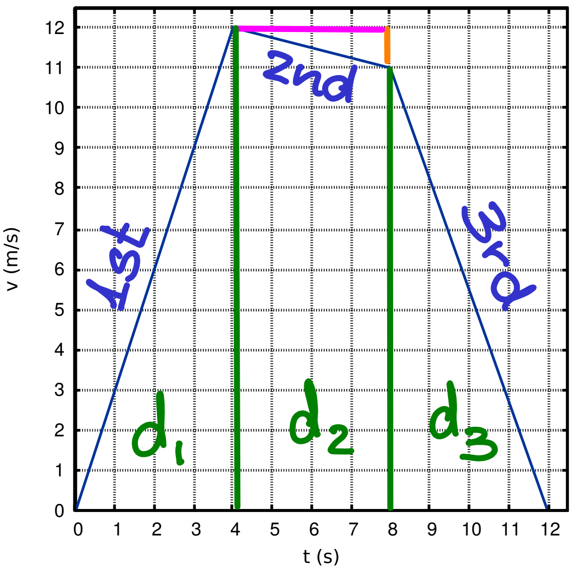
nagytibo@msu

Please, sit in row D.

1 pt Are you sitting in the seat assigned?

1.A ◯ Yes, I am.

A car is waiting at an intersection. When the traffic light turns green, the car starts moving. After some time the car comes to rest at another traffic light. The figure below shows the velocity of the car as a function of time.



$\Delta v = -1 m/s$

$\Delta t = 4s$

$d_1 = \frac{0+12}{2} \cdot 4 = 24 m$

$d_2 = \frac{12+11}{2} \cdot 4 = 46 m$

$d_3 = \frac{11+0}{2} \cdot 4 = 22 m$

One can clearly identify three different stages of this motion.

$\boxed{3\ pt}$ What is the acceleration of the car during the second stage of the motion?
(in `m/s^2`*)*

2. **A**◯ -0.500 **B**◯ -0.333 **C**◯ -0.250 **D**◯ -0.167
E◯ 0 **F**◯ 0.167 **G**◯ 0.333 **H**◯ 0.500

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

$a = -\frac{1 m/s}{4s} = -0.25 m/s^2$

$\boxed{3\ pt}$ What is the total distance travelled by the car between the two traffic lights?
(in `m`*)*

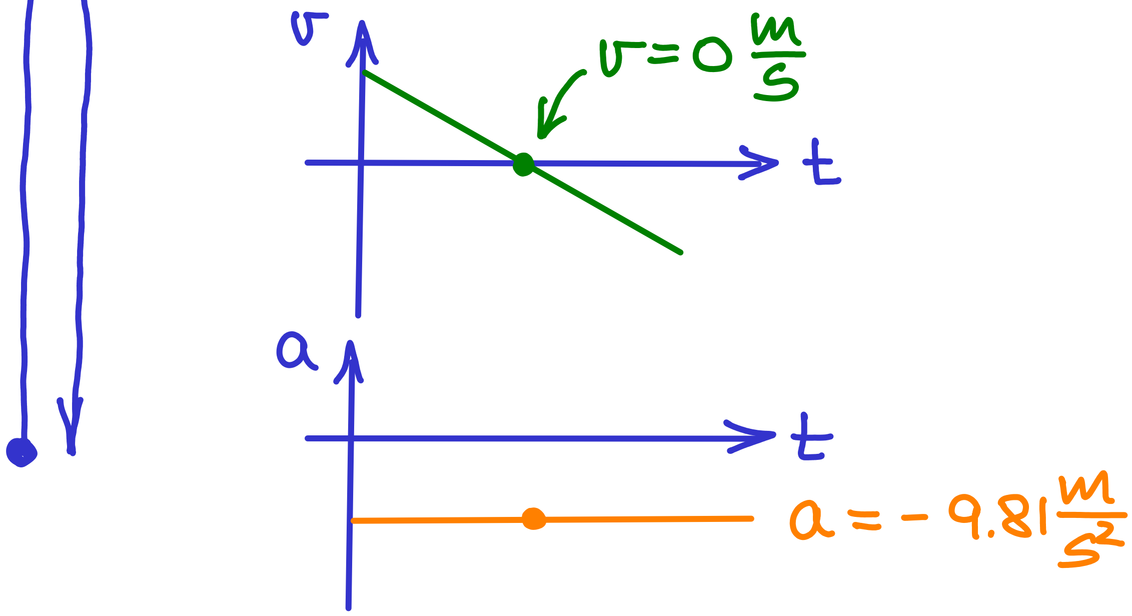
3. **A**◯ 39.1 **B**◯ 52.0 **C**◯ 69.2 **D**◯ 92.0 **E**◯ 122 **F**◯ 163 **G**◯ 216 **H**◯ 288

The area under the v versus t graph is equal to the distance travelled. The three slices are: $d_1 = 24 m$, $d_2 = 46 m$ and $d_3 = 22 m$. The total distance is the sum of these: $d = d_1 + d_2 + d_3 = 92 m$.

$\boxed{4\ pt}$ A tennis ball is tossed straight up into the air. It flies up, it reaches the peak position, and then it falls back down. What can we tell about the ball's velocity and acceleration, when the ball is at the peak of its trajectory? (Only one answer is correct.)

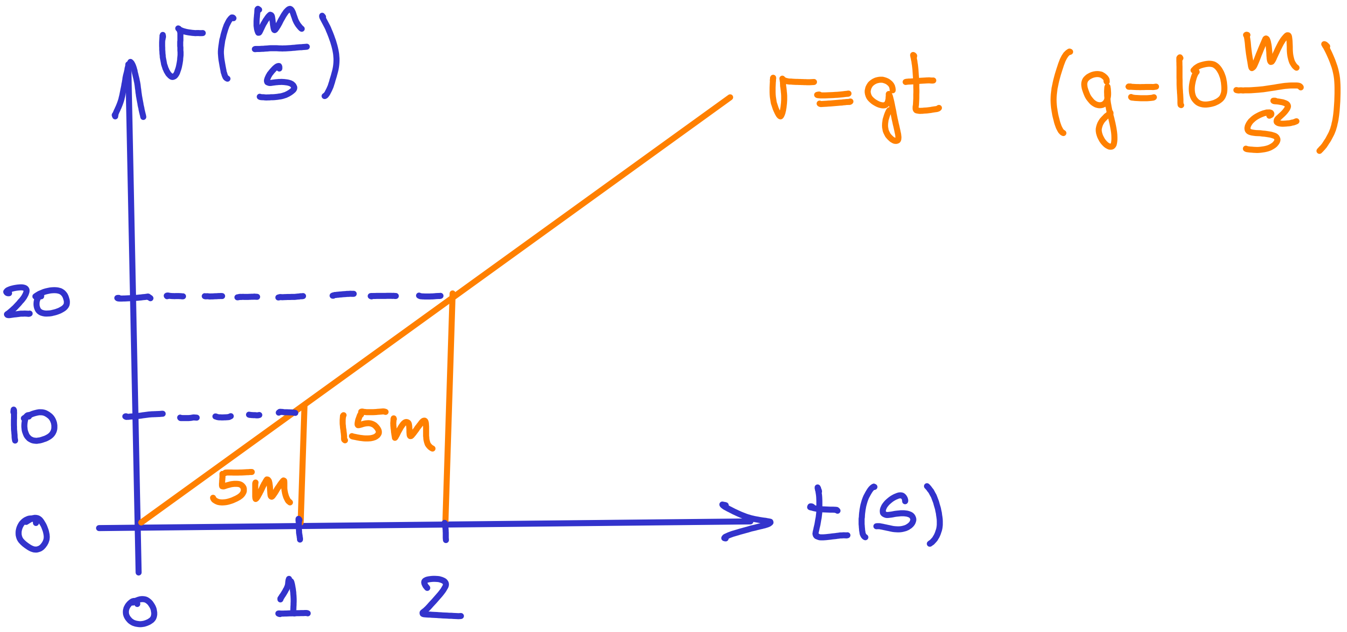
4.A◯ Both the velocity and the acceleration are zero.
B◯ The velocity is zero, and the acceleration points up.
C◯ The velocity points up, and the acceleration is zero.
D◯ Both the velocity and the acceleration point down.
E◯ The velocity is zero, and the acceleration points down.
F◯ The velocity points down, and the acceleration is zero.
G◯ Both the velocity and the acceleration point up.
H◯ The velocity points down, and the acceleration points up.
I◯ The velocity points up, and the acceleration points down.

$v = 0\ \frac{m}{s}$ and $g = 9.81\ \frac{m}{s^2}$ down



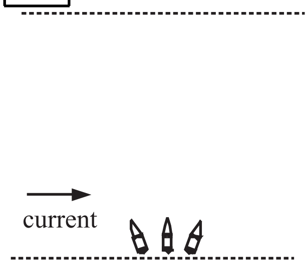
$\boxed{4\ pt}$ A large rock is released from rest from the top of a tall building. The average speed of the rock during the first second of the fall is 5 m/s. What is the average speed of the rock during the next second?

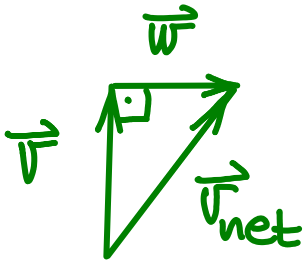
5.A◯ 50 m/s
B◯ 15 m/s
C◯ 100 m/s
D◯ 20 m/s
E◯ 30 m/s
F◯ 0 m/s
G◯ 5 m/s
H◯ 10 m/s
I◯ 25 m/s



5 : 15 = 1 : 3 (Galileo Galilei)

$\boxed{4\ pt}$ A boat crossing a 153.0 m wide river is directed so that it will cross the river as quickly as possible.





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

The boat has a speed of 6.10 m/s in still water and the river flows uniformly at 4.30 m/s. Calculate the total distance the boat will travel to reach the opposite shore.
(in m*)*

6. **A**◯ 9.88×10^1 **B**◯ 1.07×10^2 **C**◯ 1.16×10^2 **D**◯ 1.26×10^2
E◯ 1.44×10^2 **F**◯ 1.53×10^2 **G**◯ 1.87×10^2 **H**◯ 2.06×10^2

Time to cross: $t = \frac{d}{v} = \frac{153\text{m}}{6.1\text{m/s}} = 25.1\text{s}$

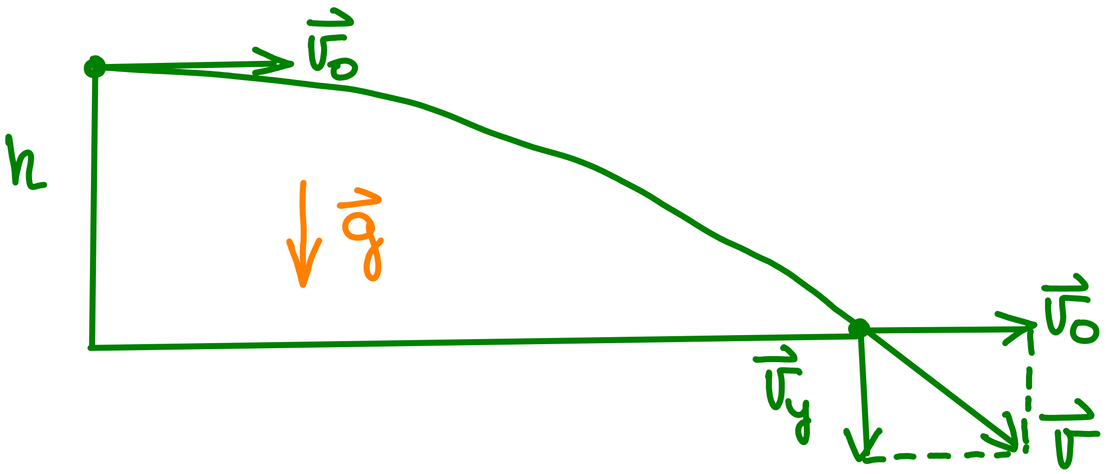
$v_{net} = \sqrt{v^2 + w^2} = \sqrt{6.1^2 + 4.3^2} = 7.46\text{m/s}$

Total distance travelled: $D = v_{net} \cdot t$

$D = 7.46\text{m/s} \cdot 25.1\text{s} = 187\text{m}$

$\boxed{4\ pt}$ A baseball is projected horizontally with an initial speed of 5.47 m/s from a height of 1.70 m. What is the speed of the baseball when it hits the ground? (Neglect air friction.)
(in m/s*)*

7. **A**◯ 3.26 **B**◯ 4.07 **C**◯ 5.09 **D**◯ 6.36
E◯ 7.95 **F**◯ 9.94 **G**◯ 1.24×10^1 **H**◯ 1.55×10^1



$\vec{v}_0$ remains constant

$v_y^2 = 2gh$ ($h = \frac{1}{2}gt^2$ & $v = gt$ combined)

Pythagorean theorem:

$v^2 = v_0^2 + v_y^2 \Rightarrow v = \sqrt{v_0^2 + 2gh}$

$v = \sqrt{5.47^2 + 2 \cdot 9.81 \cdot 1.70} = 7.95\,\text{m}$

4 pt The International Space Station (ISS) flies on a circular orbit with a speed of 7.71 km/s at a height of 330.0 km above the surface of the Earth. What is the centripetal acceleration of the station? (The radius of the Earth is 6371 km.)
(in `m/s^2`*)*

8. **A**◯ 8.87 **B**◯ 1.11×10^1 **C**◯ 1.39×10^1 **D**◯ 1.73×10^1
E◯ 2.17×10^1 **F**◯ 2.71×10^1 **G**◯ 3.38×10^1 **H**◯ 4.23×10^1

$$a_{cp} = \frac{v^2}{r}$$

$$v = 7.71\ km/s = 7{,}710\ m/s$$

$$r = R_E + h = 6371 + 330 = 6701\ km = 6.7 \cdot 10^6\ m$$

$$a_{cp} = \frac{7{,}710^2}{6.7 \cdot 10^6} = 8.87\ \frac{m}{s^2}$$

The gravitational acceleration at 330 km above the surface of the Earth is $8.87\ m/s^2$. It is somewhat less than the gravitational acceleration on the surface ($9.81\ m/s^2$).

$\boxed{4\ pt}$ Two forces $\mathbf{F_1}$ = -6.50**i** + 7.60**j** and $\mathbf{F_2}$ = 8.30**i** + 5.60**j** are acting on a mass of m = 4.00 kg. The forces are measured in newtons. What is the magnitude of the object's acceleration?
(in `m/s^2`*)*

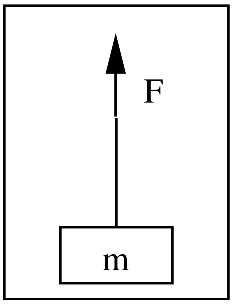
9. **A**◯ 1.81 **B**◯ 2.04 **C**◯ 2.31 **D**◯ 2.61 **E**◯ 2.95 **F**◯ 3.33 **G**◯ 3.76 **H**◯ 4.25

$$\vec{F}_1 = -6.5\hat{i} + 7.6\hat{j}$$
$$\vec{F}_2 = 8.3\hat{i} + 5.6\hat{j}$$
$$\vec{F}_{net} = 1.8\hat{i} + 13.2\hat{j}$$
$$F_{net} = |\vec{F}_{net}| = \sqrt{1.8^2 + 13.2^2} = 13.3\,N$$

Newton's second law :

$$\vec{a} = \frac{\vec{F}_{net}}{m} \Rightarrow a = \frac{F_{net}}{m} = \frac{13.3N}{4kg} = 3.33\,kg$$

An m = 7.75 kg mass is suspended on a string which is pulled upward by a force of F = 81.3 N as shown in the figure.



$F = 81.3\,N$

$mg = 7.75\,kg \cdot 9.81\,\frac{m}{s^2} = 76.0\,N$

4 pt If the upward velocity of the mass is 3.25 m/s right now, then what is the velocity 2.50 s later?
(in m/s*)*

10. **A**◯ 3.42 **B**◯ 4.96 **C**◯ 7.19 **D**◯ 1.04×10^1
E◯ 1.51×10^1 **F**◯ 2.19×10^1 **G**◯ 3.18×10^1 **H**◯ 4.61×10^1

$F_{net} = F - mg = 5.27\,N$

Newton's second law: $a = \frac{F_{net}}{m} =$

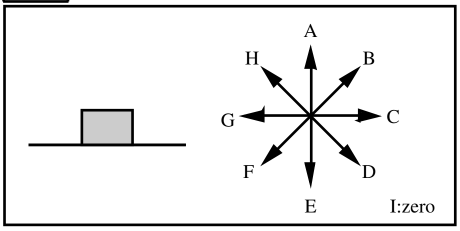
$= \frac{5.27\,N}{7.75\,kg} = 0.68\,m/s^2$

$a = \frac{\Delta v}{\Delta t} \Rightarrow \Delta v = a \cdot \Delta t = 0.68\,\frac{m}{s^2} \cdot 2.5\,s$

$\Delta v = 1.7\,m/s$

$v = v_0 + \Delta v = 3.25\,\frac{m}{s} + 1.7\,\frac{m}{s} = 4.95\,\frac{m}{s}$

$\boxed{\textit{3 pt}}$ A block is at rest on a horizontal surface. (See figure.)



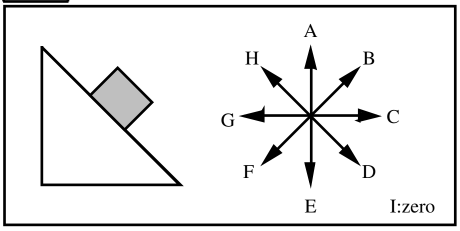
The block is at rest.
Therefore $\vec{F}_{net} = 0$.

Which vector best represents the direction of the force exerted by the surface on the block?

11.A◯ A
B◯ B
C◯ C
D◯ D
E◯ E
F◯ F
G◯ G
H◯ H
I◯ I: the force is zero.

$$\left.\begin{array}{l}\vec{F}\\ \\ m\vec{g}\end{array}\right\}\vec{F}_{net} = 0$$

$\boxed{\textit{3 pt}}$ A block is at rest on a frictional incline. (See figure.)



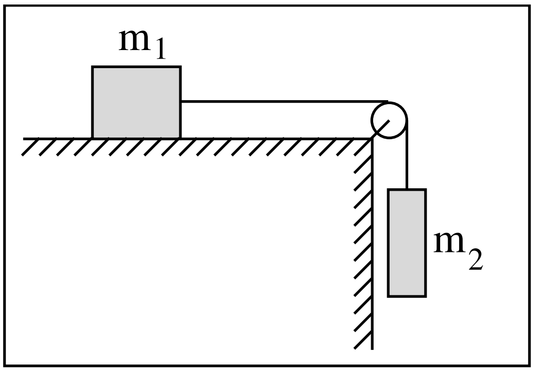
The block is at rest.
Therefore $\vec{F}_{net} = 0$.

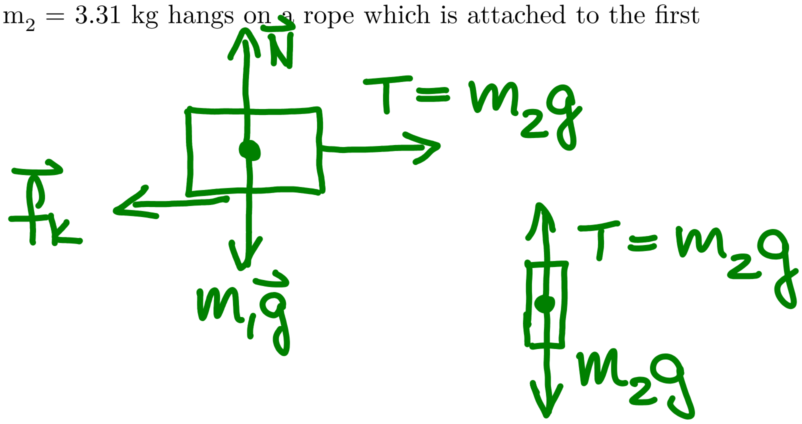
Which vector best represents the direction of the force exerted by the surface on the block?

12.A◯ A
B◯ B
C◯ C
D◯ D
E◯ E
F◯ F
G◯ G
H◯ H
I◯ I: the force is zero.

$$\left.\begin{array}{l}\vec{F}\\ m\vec{g}\end{array}\right\}\vec{F}_{net} = 0$$

5 pt Mass $m_1 = 14.1$ kg is on a horizontal table. Mass $m_2 = 3.31$ kg hangs on a rope which is attached to the first mass using a pulley. (See figure.)





The pulley is massless and frictionless. The system is observed to move with constant speed. Determine μ_k, the coefficient of kinetic friction between mass m_1 and the surface of the table.

13. **A**◯ 0.163 **B**◯ 0.184 **C**◯ 0.208 **D**◯ 0.235
E◯ 0.265 **F**◯ 0.300 **G**◯ 0.339 **H**◯ 0.383

Constant speed means $\vec{a} = 0$ for both objects, and $\vec{F}_{net} = 0$ for both objects.

Object #2 : $m_2 g = T$ (y direction)
Object #1 : $m_1 g = N$ (y direction)
$T = f_k$ (x direction)

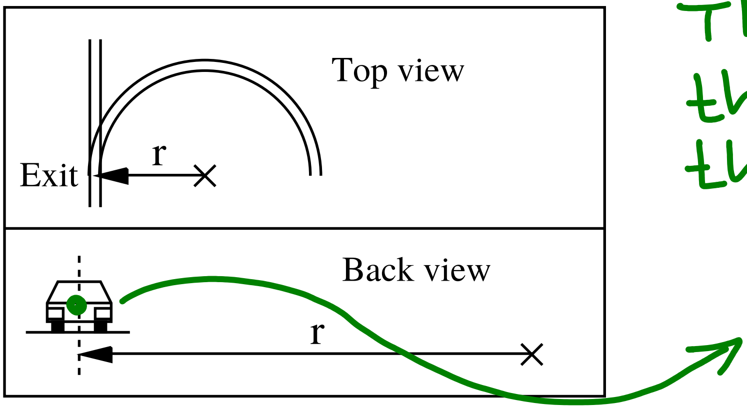
Kinetic friction : $f_k = \mu_k \cdot N$

All of these combined:

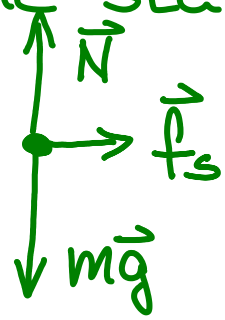
$$m_2 g = \mu_k \cdot m_1 g$$

$$\frac{m_2}{m_1} = \mu_k \Rightarrow \mu_k = \frac{3.31\,\text{kg}}{14.1\,\text{kg}} = 0.235$$

The radius of curvature of a highway exit is r = 92.5 m. The surface of the exit road is horizontal, not banked. (See figure.)



The car is kept on the exit ramp by the static friction:



$\boxed{4\ pt}$ 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 59.5 km/h?

14. **A**◯ 3.01×10^{-1} **B**◯ 3.52×10^{-1} **C**◯ 4.12×10^{-1} **D**◯ 4.82×10^{-1}
E◯ 5.64×10^{-1} **F**◯ 6.60×10^{-1} **G**◯ 7.72×10^{-1} **H**◯ 9.03×10^{-1}

$59.5\,\mathrm{km/h} =$
$= 16.5\,\mathrm{m/s}$

Newton's second law for the car:

y-comp: $N - mg = 0 \Rightarrow N = mg$

x-comp: $f_s = m a_{cp}$

static friction: $f_{s,max} = \mu_s \cdot N$

centripetal acceleration: $a_{cp} = \frac{v^2}{r}$

All of these combined:

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

$$\mu_s = \frac{v^2}{gr} = \frac{(16.5\,\mathrm{m/s})^2}{9.81\frac{\mathrm{m}}{\mathrm{s}^2} \cdot 92.5\,\mathrm{m}} = 0.301$$