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 H.

1 pt Are you sitting in the seat assigned?

1.A ◯ Yes, I am.

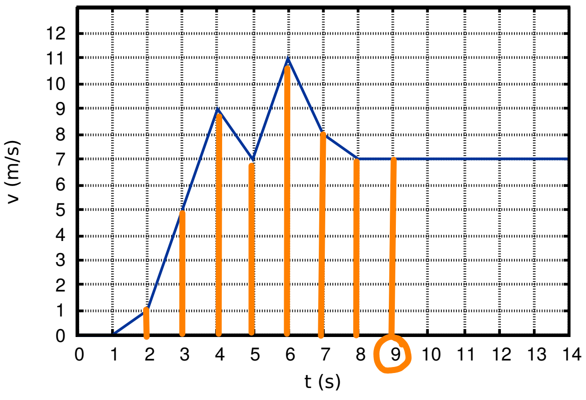
4 pt An apple, a brick and a hammer are all dropped from the second floor of a building at the same time. Which object(s) will hit the ground first?

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

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

Galileo Galilei

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



Slice up the v-vs-t graph to 1 second slices, and calculate the area of all these trapezoids.

5 pt How much distance did the car cover in the first 9 seconds?
(in m)

3. **A**◯ 42.0 **B**◯ 43.5 **C**◯ 46.5 **D**◯ 51.5 **E**◯ 54.5 **F**◯ 58.0 **G**◯ 59.5 **H**◯ 61.0

$$\frac{0+0}{2}\cdot 1+\frac{0+1}{2}\cdot 1+\frac{1+5}{2}\cdot 1+\frac{5+9}{2}\cdot 1+$$

$$+\frac{9+7}{2}\cdot 1+\frac{7+11}{2}\cdot 1+\frac{11+8}{2}\cdot 1+\frac{8+7}{2}\cdot 1+\frac{7+7}{2}\cdot 1=$$

$$=0+0.5+3+7+8+9+9.5+7.5+7=$$

$$=51.5\ m$$

5 pt A car, on a straight road, is stopped at a traffic light. When the light turns to green, the car accelerates away with a constant acceleration of 3.57 m/s^2. The car travels for a distance of 106 m with this constant acceleration before it starts cruising. What is the speed reached by the car?
(in `m/s`*)*

4. **A**◯ 1.17×10^1 **B**◯ 1.32×10^1 **C**◯ 1.49×10^1 **D**◯ 1.69×10^1
E◯ 1.91×10^1 **F**◯ 2.15×10^1 **G**◯ 2.43×10^1 **H**◯ 2.75×10^1

$$v^2 = 2ad$$

$$v = \sqrt{2ad} = \sqrt{2 \cdot 3.57 \cdot 106}$$

$$v = 27.5 \text{ m/s}$$

3 pt An artillery shell is launched on a flat, horizontal field at an angle of $\alpha = 44.8°$ with respect to the horizontal and with an initial speed of $v_0 = 297$ m/s. What is the horizontal velocity of the shell after 30.27 s of flight? (Neglect air friction. Use the coordinate system where the x-axis is horizontal and points to the right; and the y-axis is vertical and points up.)
(in m/s*)*

5. **A**◯ 1.12×10^2 **B**◯ 1.32×10^2 **C**◯ 1.54×10^2 **D**◯ 1.80×10^2
E◯ 2.11×10^2 **F**◯ 2.47×10^2 **G**◯ 2.88×10^2 **H**◯ 3.38×10^2

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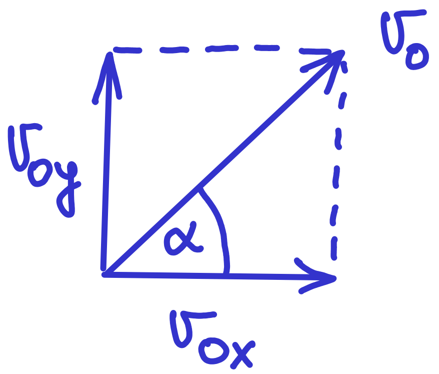
3 pt What is the vertical velocity of the shell at this moment?
(in m/s*)*

6. **A**◯ -2.19×10^2 **B**◯ -1.75×10^2 **C**◯ -1.31×10^2 **D**◯ -8.76×10^1
E◯ 8.76×10^1 **F**◯ 1.31×10^2 **G**◯ 2.19×10^2 **H**◯ 2.63×10^2



$v_0 = 297\ m/s$

$\alpha = 44.8°$

$v_{0x} = v_0 \cdot \cos\alpha$

$v_{0x} = 210.7\ \frac{m}{s} \approx 211\ \frac{m}{s}$

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

$v_{0y} = 209.3\ \frac{m}{s}$

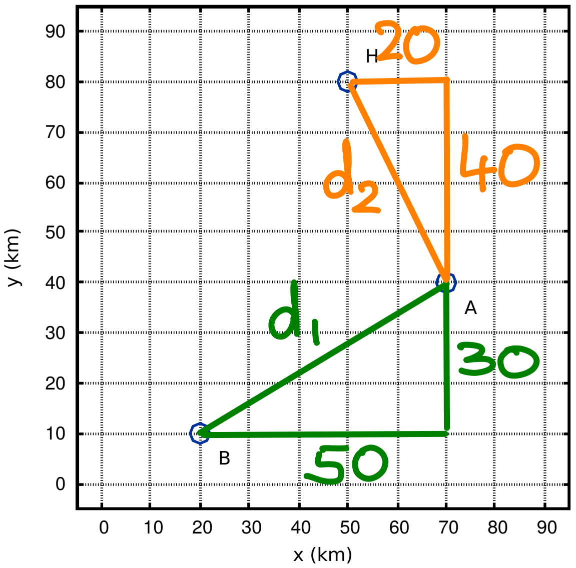
$v_x(t) = v_{0x} = 211\ m/s$

$v_y(t) = v_{0y} - gt = 209.3 - 9.81 \cdot 30.27 =$

$= -87.6\ m/s$

The shell is moving to the right and downward. It is returning.

5 pt A rescue helicopter is called to a car accident. The helicopter is stationed at an air base marked with B on the map.



$D = d_1 + d_2$

$d_1 = \sqrt{50^2 + 30^2} = \sqrt{3400} =$

$= 58.31$ km

$d_2 = \sqrt{40^2 + 20^2} = \sqrt{2000} =$

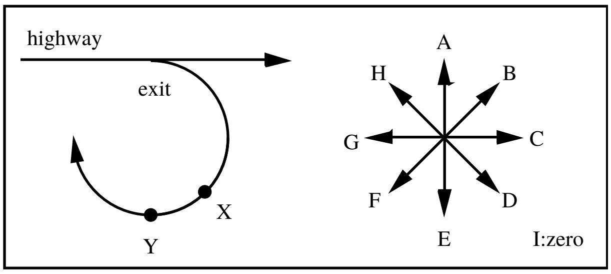
$= 44.72$ km

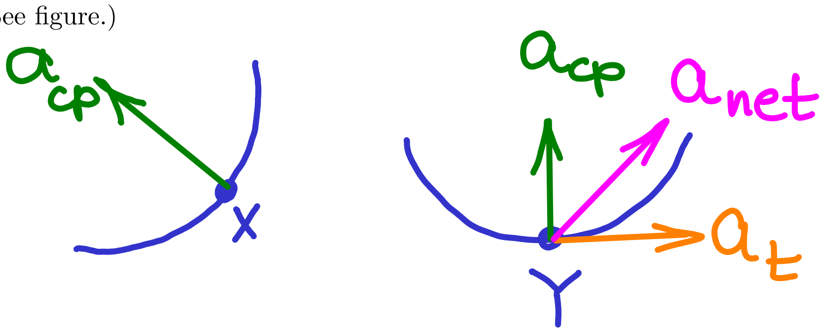
$D = 103$ km

The helicopter takes off and flies to the accident on a straight line. The accident is labeled with an A. The helicopter picks up the patient and flies to the hospital on a straight line. The hospital is labeled with an H. How much total distance did the helicopter cover?
(in km*)*

7. **A**◯ 4.90×10^1 **B**◯ 7.11×10^1 **C**◯ 1.03×10^2 **D**◯ 1.49×10^2
E◯ 2.17×10^2 **F**◯ 3.14×10^2 **G**◯ 4.55×10^2 **H**◯ 6.60×10^2

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





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?

8.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.

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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**?

9.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 towacd the center and backwards at the same time : a_{cp} : A , a_t : C , a_{net} : B.

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4 pt Two forces $\mathbf{F_1}$ = -8.10**i** + 4.10**j** and $\mathbf{F_2}$ = 7.00**i** + 3.90**j** are acting on an object with a mass of m = 3.10 kg. The forces are measured in newtons, **i** and **j** are the unit vectors. What is the magnitude of the object's acceleration? *(in* `m/s^2`*)*

10. **A**◯ 1.33 **B**◯ 1.67 **C**◯ 2.08 **D**◯ 2.60 **E**◯ 3.26 **F**◯ 4.07 **G**◯ 5.09 **H**◯ 6.36

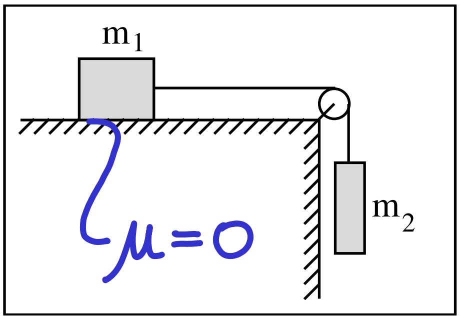
$$\vec{F}_1 = -8.10\hat{i} + 4.10\hat{j}$$
$$\vec{F}_2 = 7.00\hat{i} + 3.90\hat{j}$$
$$\vec{F}_{net} = -1.10\hat{i} + 8.00\hat{j}$$

$$F_{net} = |\vec{F}_{net}| = \sqrt{(-1.10)^2 + 8.00^2}$$

$$F_{net} = \sqrt{1.21 + 64.0} = 8.07\text{ N}$$

$$a = \frac{F_{net}}{m} = \frac{8.07\text{N}}{3.10\text{kg}} = 2.60\text{ m/s}^2$$

5 pt Mass m_1 is on a horizontal, frictionless surface. Mass $m_2 = 7.37$ kg hangs on a rope which is attached to the first mass. (See figure.)



In words: the weight of m_2 is accelerating the whole system of $(m_1 + m_2)$.

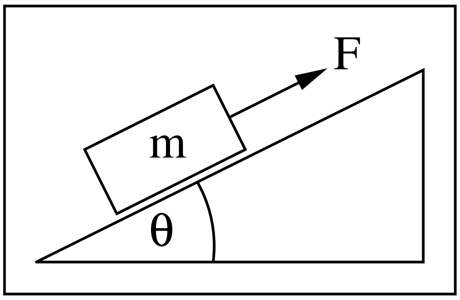
The whole system is observed to be accelerating with an acceleration of a = 3.22 m/s^2. Determine the mass m_1. Consider the pulley to be massless and frictionless.
(in kg*)*

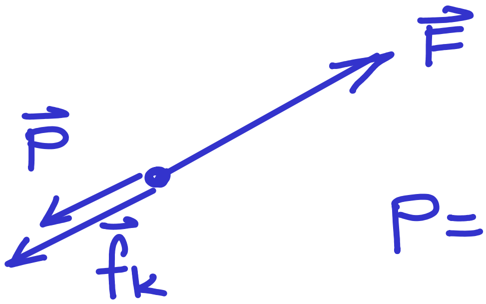
11. **A**◯ 6.41 **B**◯ 7.24 **C**◯ 8.19 **D**◯ 9.25
E◯ 1.05×10^1 **F**◯ 1.18×10^1 **G**◯ 1.33×10^1 **H**◯ 1.51×10^1

Newton's second law:

$$m_2 g = (m_1 + m_2)a$$
$$m_2 g = m_1 a + m_2 a$$
$$\frac{m_2 g - m_2 a}{a} = m_1$$
$$m_1 = \frac{7.37 \cdot 9.81 - 7.37 \cdot 3.22}{3.22}$$
$$m_1 = 15.1 \text{ kg}$$

5 pt A force **F**, with a magnitude of 18.50 N, acts on an object with a mass of m = 1.16 kg parallel to the plane of the incline as shown in the figure.





$P = mg\sin\theta$

The angle of the incline is $\theta = 43.6°$. The object is observed to move at a constant velocity of 2.39 m/s up on the incline. Calculate the magnitude of the frictional force acting on the object.
(in N*)*

12. **A**◯ 5.68 **B**◯ 6.65 **C**◯ 7.78 **D**◯ 9.10
E◯ 1.07×10^1 **F**◯ 1.25×10^1 **G**◯ 1.46×10^1 **H**◯ 1.71×10^1

Constant velocity means the acceleration is zero. Zero acceleration means the net force is zero:

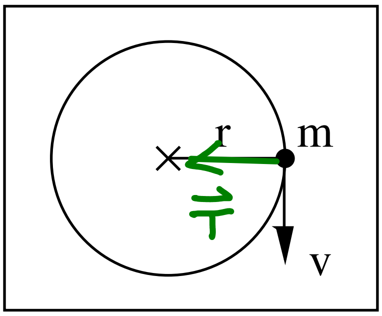
$$F_{net} = 0 \Rightarrow F - P - f_k = 0 \Rightarrow$$

$$F - P = f_k \Rightarrow f_k = F - mg\sin\theta$$

$$f_k = 18.5 - 1.16 \cdot 9.81 \cdot \sin 43.6°$$

$$f_k = 10.65\,N \approx 10.7\,N$$

A small object with a mass of m = 677 g is whirled at the end of a rope in a vertical circle with a radius of r = 121 cm.



$m = 677\ g = 0.677\ kg$

$r = 121\ cm = 1.21\ m$

$v = 4.42\ m/s$

4 pt When the object is at the location shown - mid-height -, its speed is v = 4.42 m/s. Determine the tension in the rope.
(in N)

13. **A** ◯ 1.71 **B** ◯ 2.47 **C** ◯ 3.59 **D** ◯ 5.20
E ◯ 7.54 **F** ◯ 1.09×10^{1} **G** ◯ 1.58×10^{1} **H** ◯ 2.30×10^{1}

$$a_{cp} = \frac{v^2}{r} = \frac{4.42^2}{1.21} = 16.1\ m/s^2$$

The tension T in the rope is the force responsible for this centripetal acceleration, because the weight mg is in the vertical direction.

Newton's second law in the radial direction is:

$$T = m a_{cp} = 0.677 \cdot 16.1 = 10.9\ N$$

(Newton's second law in the tangential direction is: $mg = ma_t$ $\Rightarrow a_t = g$.)