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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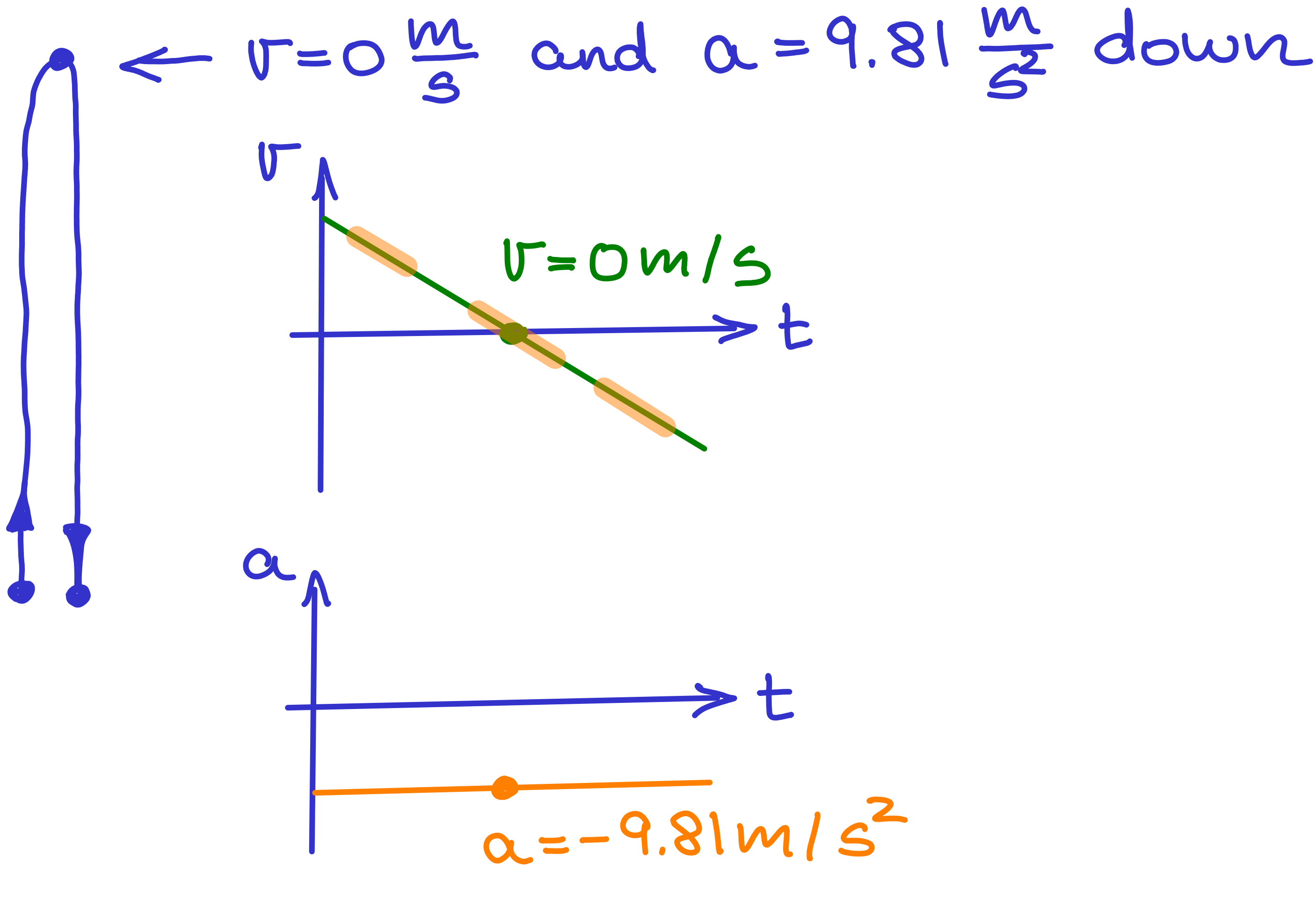
Please, sit in row J.

1 pt Are you sitting in the seat assigned?

1.A ◯ Yes, I am.

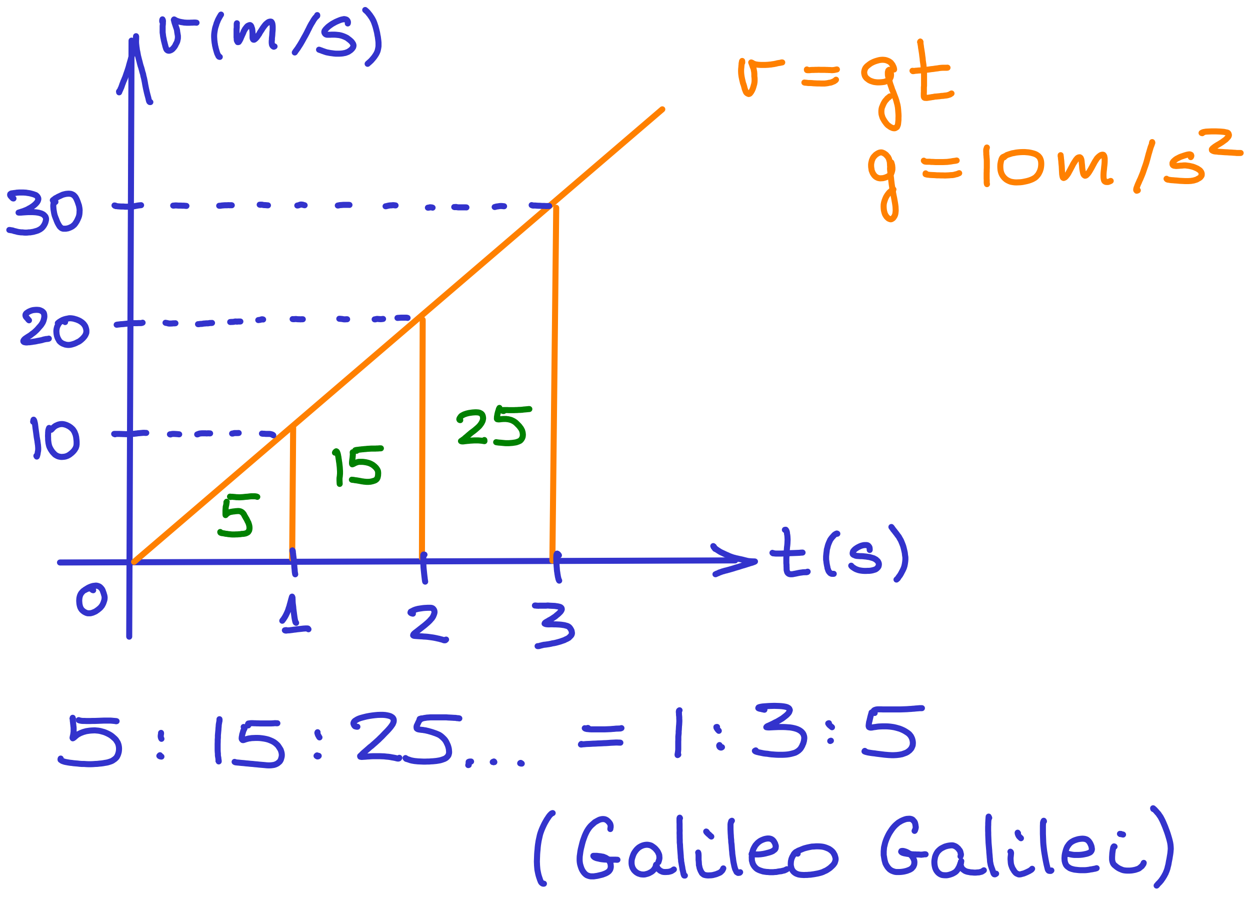
4 pt A tennis ball is tossed straight up into the air. It flies up, it reaches the peak position, and then it falls back down. What can we tell about the ball's velocity and acceleration, when the ball is at the peak of its trajectory? (Only one answer is correct.)

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

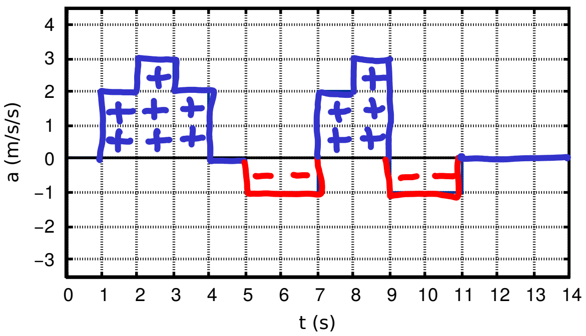


4 pt A large rock is released from rest from the top of a tall building. The average speed of the rock during the first second of the fall is 5 m/s. What is the average speed of the rock during the third second? (In this question we use the approximate value of 10 m/s^2 for the gravitational acceleration.)

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



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.



Definition of acceleration:

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

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

| 5 pt | What is the speed of the car at t=12 s?

(in m/s*)*

4. **A**◯ 3.0 **B**◯ 4.0 **C**◯ 6.0 **D**◯ 7.0 **E**◯ 8.0 **F**◯ 10.0 **G**◯ 11.0 **H**◯ 12.0

$v_0 = 0\,m/s$ i.e. rest

$\Delta v = +2+3+2-1-1+2+3-1-1 = 8\,m/s$

$v = v_0 + \Delta v = 8\,m/s$

4 pt A small, single engine airplane is about to take off. The airplane becomes airborne, when its speed reaches 115.0 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 2.60 m/s^2. What is the minimum required length of the runway?
(in m*)*

5. **A**◯ 6.54×10^1 **B**◯ 7.65×10^1 **C**◯ 8.95×10^1 **D**◯ 1.05×10^2
E◯ 1.23×10^2 **F**◯ 1.43×10^2 **G**◯ 1.68×10^2 **H**◯ 1.96×10^2

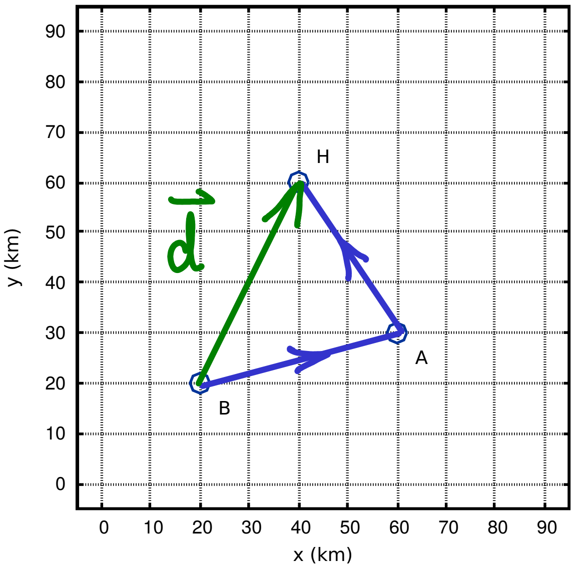
3.6 km/h = 1 m/s } 1 km = 1000 m, 1 h = 3600 s

therefore 115 km/h = 31.9 m/s

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

$$d = \frac{31.9^2}{2 \cdot 2.6} \cong 196\,\text{m}$$

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



Pythagorean theorem:

$d = \sqrt{20^2 + 40^2}$

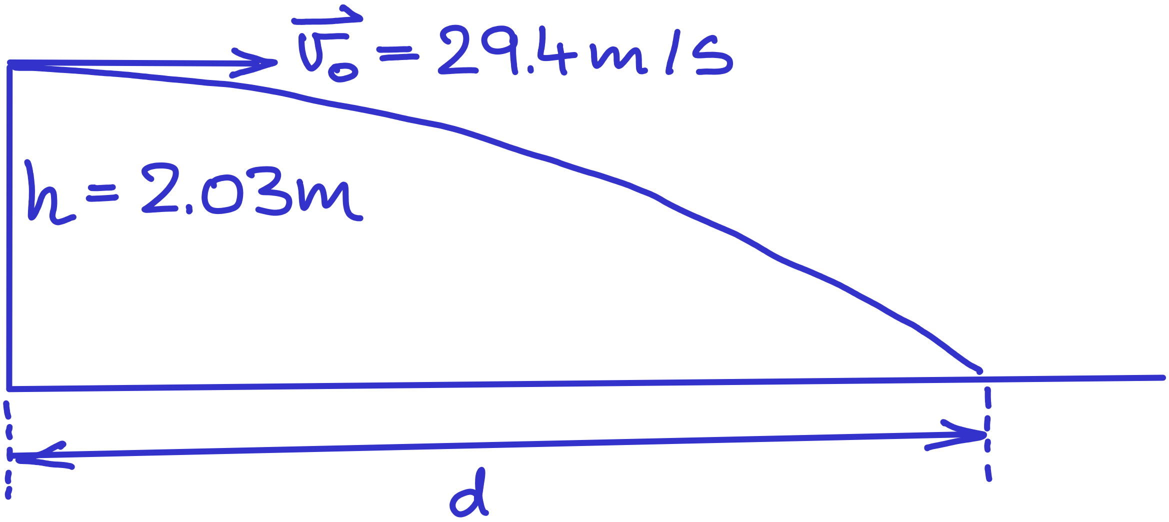
$d = 44.7$ km

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. What is the magnitude of helicopter's displacement after it lands at the hospital?
(in km*)*

6. **A**◯ 1.83×10^1 **B**◯ 2.29×10^1 **C**◯ 2.86×10^1 **D**◯ 3.58×10^1
E◯ 4.47×10^1 **F**◯ 5.59×10^1 **G**◯ 6.99×10^1 **H**◯ 8.73×10^1

5 pt A baseball is projected horizontally with an initial speed of 29.4 m/s from a height of 2.03 m. At what horizontal distance will the ball hit the ground? (Neglect air friction.)
(in m*)*

7. **A**◯ 1.89×10^1 **B**◯ 2.52×10^1 **C**◯ 3.35×10^1 **D**◯ 4.45×10^1
E◯ 5.92×10^1 **F**◯ 7.87×10^1 **G**◯ 1.05×10^2 **H**◯ 1.39×10^2



Free fall in the vertical direction:

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

Constant velocity motion in the horizontal direction: $d = v_0 \cdot t$

$d = v_0 \cdot \sqrt{\frac{2h}{g}} = 29.4 \cdot \sqrt{\frac{2 \cdot 2.03}{9.81}} = 18.9\,m$

4 pt Two forces $\mathbf{F_1}$ = -5.90**i** + 5.00**j** and $\mathbf{F_2}$ = 7.20**i** + 3.50**j** are acting on an object. The forces are measured in newtons, **i** and **j** are the unit vectors. The magnitude of the object's acceleration is observed to be 3.50 m/s^2. What is the mass of the object?
(in kg*)*

8. **A**◯ 8.05×10^{-1} **B**◯ 1.01 **C**◯ 1.26 **D**◯ 1.57
E◯ 1.97 **F**◯ 2.46 **G**◯ 3.07 **H**◯ 3.84

$\vec{F}_1 : -5.90\hat{i} + 5.00\hat{j}$

$\vec{F}_2 : 7.20\hat{i} + 3.50\hat{j}$

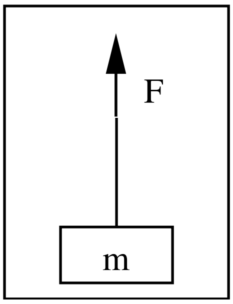
$\vec{F}_{net} : 1.30\hat{i} + 8.50\hat{j}$

$F_{net} = |\vec{F}_{net}| = \sqrt{1.30^2 + 8.50^2} = 8.6\,N$

Newton's 2nd law: $F_{net} = m \cdot a$

$\Rightarrow m = \frac{F_{net}}{a} = \frac{8.6N}{3.5\frac{m}{s}} = 2.46\,kg$

An m = 7.75 kg mass is suspended on a string which is pulled upward by a force of F = 79.9 N as shown in the figure.



Forces acting on mass m:

$\vec{F} = 79.9\,N$

m

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

4 pt If the upward velocity of the mass is 2.25 m/s right now, then what is the velocity 3.50 s later? *(in m/s)*

9. **A**◯ 3.02 **B**◯ 4.01 **C**◯ 5.34 **D**◯ 7.10
E◯ 9.44 **F**◯ 1.26×10^1 **G**◯ 1.67×10^1 **H**◯ 2.22×10^1

Net force:

$F_{net} = F - mg = 3.87\,N$

Newton's 2nd law:

$$a = \frac{F_{net}}{m} = \frac{3.87\,N}{7.75\,kg} = 0.499\,\frac{m}{s^2}$$

Definition of acceleration:

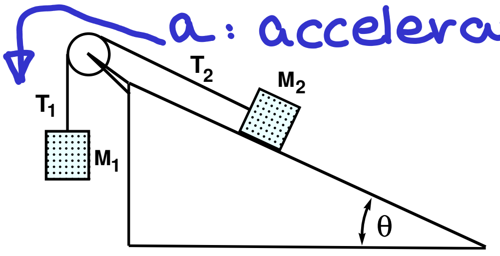
$$a = \frac{\Delta v}{\Delta t} \Rightarrow \Delta v = a \cdot \Delta t = $$
$$= 0.499\,\frac{m}{s^2} \cdot 3.50\,s = 1.75\,\frac{m}{s}$$

Change in velocity: $\Delta v = v_f - v_i \Rightarrow$

$$\Rightarrow v_f = v_i + \Delta v = 2.25\,\frac{m}{s} + 1.75\,\frac{m}{s} =$$
$$= 4.00\,\frac{m}{s}$$

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.

a: acceleration



We know that
→ $M_1 = M_2$
→ the pulley is ideal
→ the incline is frictionless

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

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

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

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

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

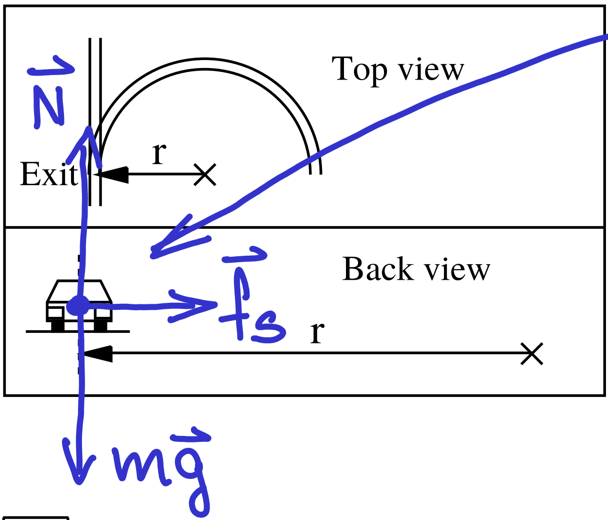
$M_1g > T_1 = T_2 > M_2g \cdot \sin(\theta)$

$M_1g = M_2g$ b/c $M_1 = M_2$

$T_1 = T_2$ b/c the pulley is ideal

$a_1 = a_2$ b/c the rope doesn't stretch

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.)



The car is kept on the circular ramp by the sideway static friction.

5 pt What is the minimum required value of the coefficient of static friction between the tires of the car and the surface of the road so that the car can safely exit the highway at a constant speed of 50.9 km/h without sliding?

15. **A**◯ 5.94×10^{-2} **B**◯ 7.89×10^{-2} **C**◯ 1.05×10^{-1} **D**◯ 1.40×10^{-1}
E◯ 1.86×10^{-1} **F◯ 2.47×10^{-1}** **G**◯ 3.29×10^{-1} **H**◯ 4.37×10^{-1}

50.9 km/h = = 14.14 m/s

Newton's second law for the car:

vertical : $N - mg = 0 \Rightarrow N = mg$

horizontal: $f_s = m a_{cp}$

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

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

All of these combined:

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

$$\mu_s = \frac{v^2}{gr} = \frac{(14.14\,m/s)^2}{9.81\frac{m}{s^2} \cdot 82.5\,m} = 0.247$$