Name:____________

Student ID:____________

Solutions

Istanbul Medipol University
School of Engineering and Natural Sciences
General Physics 1 Midterm 1

November 17, 2018

Name	
Student ID	
Signature	

- Write your name and student ID on every page in the spaces provided above.
- *Show all your work*. Your work and answers must be shown on the pages provided.
- Your grade will be based on the correctness of your solution and the clarity of your work leading up to the solution.

Question	Points Earned
1 (25)	
2 (25)	
3 (25)	
4 (25)	
Total	

General Physics 1 Name:____________

Fall 2018 Student ID:____________

Question 1

The position of a particle is given as a function of time as $\vec{r} = \left(4t^2\hat{i} - 8t\hat{j}\right)$ meters.

a) Find the displacement vector $\Delta\vec{r}$ of the particle between $t = 1$ and $t = 4$ seconds.

b) Find the average velocity vector $\vec{v}_{avg}$ of the particle between $t = 1$ and $t = 4$ seconds.

c) Find the angle between the average velocity vector $\vec{v}_{avg}$ of the particle and the *x*-axis between $t = 1$ and $t = 4$ seconds.

d) Find the instantaneous velocity $\vec{v}$ of the particle at $t = 2$ seconds.

e) Find the instantaneous acceleration $\vec{a}$ of the particle at $t = 5$ seconds.

5 a) $\vec{r}(t=4s) = 4(4^2)\hat{i} - 8(4)\hat{j} = (64\hat{i} - 32\hat{j})\ m$ 1

$\vec{r}(t=1s) = 4(1^2)\hat{i} - 8(1)\hat{j} = (4\hat{i} - 8\hat{j})\ m$ 1

$\vec{\Delta r} = \vec{r}_4 - \vec{r}_1 = (60\hat{i} - 24\hat{j})\ m$ 2 1

5 b) $\vec{v}_{avg} = \dfrac{\vec{\Delta r}}{\Delta t} = \dfrac{60\hat{i} - 24\hat{j}}{4 - 1} = (20\hat{i} - 8\hat{j})\ m/s$ 1 2 1 1

5 c) $\tan\theta = \dfrac{v_{avg\,y}}{v_{avg\,x}} = \dfrac{20}{-8}$, $\theta = \arctan(-2.5)$ 2 1

5 d) $\vec{v} = \dfrac{d\vec{r}}{dt} = 4(2t)\hat{i} - 8\hat{j} = (8t\,\hat{i} - 8\hat{j})\ m/s$ 2 1 1

$\vec{v}(t=2s) = (16\hat{i} - 8\hat{j})\ m/s$ 1

5 e) $\vec{a} = \dfrac{d\vec{v}}{dt} = (8\hat{i})\ m/s^2$ 2 1 1

$\vec{a}(t=5s) = (8\hat{i})\ m/s^2$ 1

Name:____________

Student ID:____________

Question 1

General Physics 1 Name:____________

Fall 2018 Student ID:____________

Question 2

Joe starts from rest and finishes a 150 meter race in 18 seconds. For the first 30 meters, he runs with constant acceleration and then with constant velocity.

15 a) How long does it take for him to run the first 30 meters?

2 b) How long does it take for him to run the last 120 meters?

2 c) What is his final velocity?

2 d) What is his acceleration in the first 30 meters?

Mary is in the race. She starts from rest at the same time and runs with constant acceleration of 0.75 m/s².

2 e) Who wins the race?

2 f) At time t = 6 seconds, what is Mary's velocity relative to Joe?

Method 1 :

First 30m : $X = V_0 t + \frac{1}{2} a t^2$, $V = V_0 + a t$ 2

1 $30 = \frac{1}{2} a t_1^2$

1 $V_1 = a t_1$

substitute : $30 = \frac{1}{2} V_1 t_1$ 5

$V_1 t_1 = 60$ m

Last 120 m : $X = V_1 t$, $V = V_1$ 2

$120 = V_1 (18 - t_1)$ 2

$= 18 V_1 - V_1 t_1$

$120 = 18 V_1 - 60$

$V_1 = \frac{180}{18} = 10$ m/s

2

$V_1 t_1 = 60$ m $\rightarrow t_1 = \frac{60}{V_1} = \frac{60}{10} = 6$ s

b) 2 $t_2 = 18 - t_1 = 12$ s

2

c) Final velocity $= V_1 = 10$ m/s

d) $V_1 = a t_1$ 2

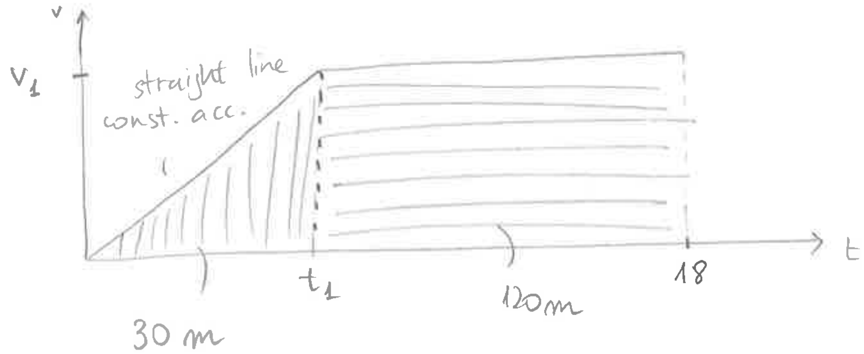
$10 = a\, 6 \rightarrow a = \frac{10}{6}$ m/s²

General Physics 1 Name:____________

Fall 2018 Student ID:____________

Question 2

Method 2:



Area under curve gives the distance:

First 30 m: $\frac{v_1 t_1}{2} = 30$ 3 $\longrightarrow$ $v_1 t_1 = 60$ m 5

Last 120 m: $v_1(18 - t_1) = 120$ m 3

$18 v_1 - v_1 t_1 = 120$ m

$18 v_1 - 60 = 120$ m

$v_1 = \frac{180 \text{ m}}{18 \text{ s}} = 10$ m/s 2

$t_1 = \frac{60}{10} = 6$ s 2

2 $t_2 = 18 - t_1 = 12$ s

2 $v_{final} = v_1 = 10$ m/s

2 a: $v_1 = a t_1 \rightarrow a = \frac{v_1}{t_1} = \frac{10}{6}$ m/s^2

2 e) $150\ m = \frac{1}{2} a_{Mary}\ t_{Mary}^2$

$150\ m = \frac{1}{2}\left(0.75\ \frac{m}{s^2}\right) t_{Mary}^2$

$t_{Mary} = \sqrt{\frac{300}{0.75}} = \sqrt{400} = 20\ s$

$t_{Joe} = 18\ s \longrightarrow$ Joe wins

2 f) $t = 6:$ $v_{Joe} = v_1 = 10\ m/s$

$v_{Mary} = a_{Mary}(6\ s) = (0.75)(6) = 4.5\ m/s$

$v_{Mary/Joe} = v_{Mary/Earth} + v_{Earth/Joe}$

$= v_{Mary/E} - v_{Joe/E}$

$v_{Mary/Joe} = 4.5 - 10 = -5.5\ m/s$

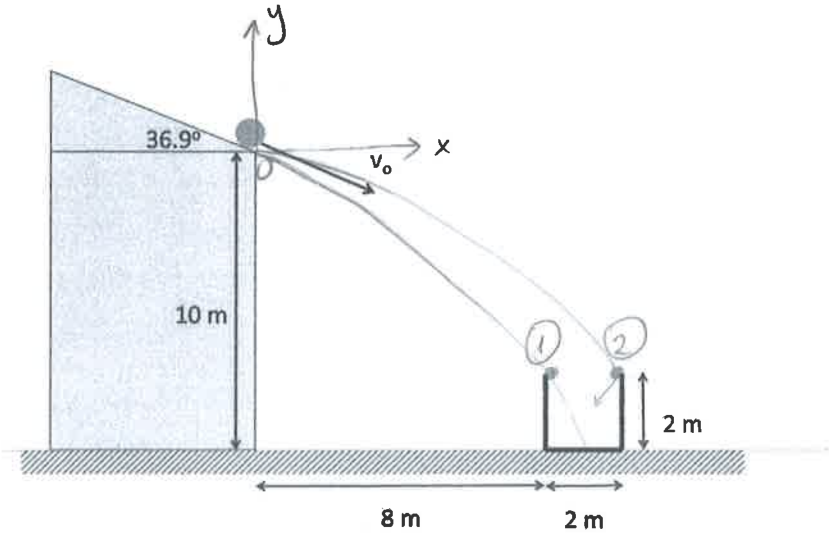
General Physics 1 Name:____________

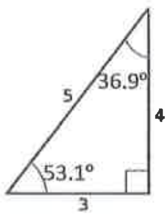
Fall 2018 Student ID:____________

Question 3

For a ball sliding off the roof with initial velocity v_0 as shown, find the range of initial velocities (v_0) for which the ball enters the container on the street. (Assume $g = 10\ m/s^2$)

(You can leave answers as square root and fractions)





2 2

$$V_{0x} = V_0 \cos 36.9° = \frac{4}{5} V_0 \quad , \quad V_{0y} = V_0 \sin 36.9° = \frac{3}{5} V_0$$

① position: right at the top of the left side of container:

$(x, y) = (8, -8)\,m$ 3

$x = V_{0x} t \; : \; 8 = \frac{4}{5} V_0 t \rightarrow t = \frac{10}{V_0}$ 2

2

$y = -V_{0y} t - \frac{1}{2} g t^2 \; : \; -8 = -\frac{3}{5} V_0 t - \frac{1}{2}(10) t^2$

$-8 = -\frac{3}{5} V_0 t - 5t^2$

$-8 = -\frac{3}{5} V_0 \left(\frac{10}{V_0}\right) - 5\left(\frac{100}{V_0^2}\right)$ 2

$8 = 6 + \frac{500}{V_0^2}$

2

$2 = \frac{500}{V_0^2} \rightarrow V_0 = \sqrt{250} = 5\sqrt{10}$

② position: right at the top of the right side of the container:

$(x, y) = (10, -8)\,m$ 3

$x = V_{0x} t \; : \; 10 = \frac{4}{5} V_0 t \rightarrow t = \frac{50}{4V_0}$ 2

$y = -V_{0y} t - \frac{1}{2} g t^2 \; : \; -8 = -\frac{3}{5} V_0 t - \frac{1}{2}(10) t^2$

$-8 = -\frac{3}{5}\left(\frac{50}{4V_0}\right) V_0 - 5\left(\frac{50}{4V_0}\right)^2$

$-8 = -\frac{15}{2} - 5\left(\frac{2500}{16 V_0^2}\right)$ 2

$8 = \frac{15}{2} + \frac{12500}{16 V_0^2}$

$\frac{1}{2} = \frac{12500}{16 V_0^2}$

2

$V_0 = \sqrt{\frac{25000}{16}} = \frac{50}{4}\sqrt{10}$

General Physics 1

Fall 2018

Name:___________

Student ID:___________

Question 3

General Physics 1 | Name:___________

Fall 2018 | Student ID:___________

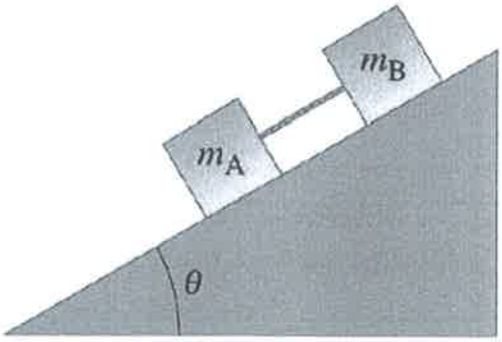
Question 4

Two blocks of equal mass $m_A = m_B = m$, connected by a massless cord of fixed length, slide down a plane ramp inclined at an angle θ to the horizontal as shown in the figure. The coefficient of kinetic friction between block A and the inclined surface is $\mu_A = \mu$, whereas the coefficient of kinetic friction between block B and the inclined surface is $\mu_B = 2\mu$.

a) Draw a free body diagram for each block.

b) Find the acceleration of the blocks in terms of m, μ, θ and the gravitational acceleration g.

c) Find the tension in the cord in terms of the above-mentioned parameters.

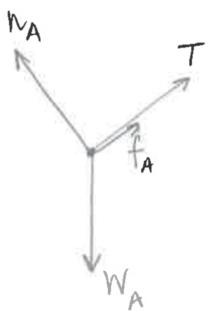


FBD for A:

FBD for B:

define coord. sys.

5



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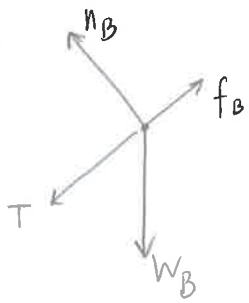
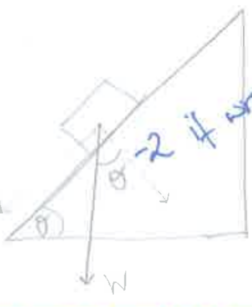


T has same magnitude

$a_A = a_B = a$ -2, if wrong

$W_A = W_B = mg$



-2 if wrong

General Physics 1 Name:____________

Fall 2018 Student ID:____________

Question 4

For A: ΣF_x : $T + f_A - mg\sin\theta = -ma$ 2.5

ΣF_y : $n_A - mg\cos\theta = 0$ 2.5

$n_A = mg\cos\theta$

$T + \mu_A n_A - mg\sin\theta = -ma$

$T + \mu mg\cos\theta - mg\sin\theta = -ma$ (1)

For B: ΣF_x : $f_B - T - mg\sin\theta = -ma$ 2.5

ΣF_y : $n_B - mg\cos\theta = 0$ 2.5

$n_B = mg\cos\theta$

$\mu_B n_B - T - mg\sin\theta = -ma$

$2\mu mg\cos\theta - T - mg\sin\theta = -ma$ (2)

$3\mu mg\cos\theta - 2mg\sin\theta = -2ma$ (1) + (2) 2.5

$-\frac{3}{2}\mu g\cos\theta + g\sin\theta = a$

$a = g\left(\sin\theta - \frac{3}{2}\mu\cos\theta\right)$

(1) : $T = mg(\sin\theta - \mu\cos\theta) - mg\left(\sin\theta - \frac{3}{2}\mu\cos\theta\right) = \frac{1}{2}mg\mu\cos\theta$ 2.5