SOLUTION

TEST # 2. PHYS 203. Chapters 6, 7, 9. Nov 6, 2022

NAME:

Rules for the exam:

1. The exam will start promptly at 5:00PM and will finish at 6:40PM.
2. No questions to the TA or Professor are allowed during the exam.
3. You can not leave the room under any circumstances.
4. You are allowed to have one cheat-sheet with no extra add-ons.
5. If you arrive to the exam after 5:15PM, you will not be allowed to do the exam.
6. You can use a calculator. No smartphones, mobile phones or any kind of computer devices are allowed during the exam.
7. No make-up under any circumstance.

Solucion

TEST # 1. PHYS 203. Chapters 2-5. FALL 2022

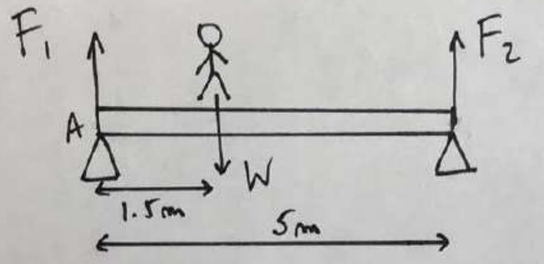
NAME:

Rules for the exam:

1. The exam will start promptly at 5:00PM and will finish at 6:40PM.
2. No questions to the TA or Professor are allowed during the exam.
3. You can not leave the room under any circumstances.
4. You are allowed to have one cheat-sheet with no extra add-ons.
5. If you arrive to the exam after 5:15PM, you will not be allowed to do the exam.
6. You can use a calculator. No smartphones, mobile phones or any kind of computer devices are allowed during the exam.
7. No make-up under any circumstance.

3. Rotational dynamics (35 points)

A 5m long board of negligible mass is supported by two pillars. One pillar is at the left end of the board, the other is at the right end of the board. A 90-kg person is standing on top of the board 1.50 m away from the left end. Find the forces exerted by the pillars. Consider that the board and the person are at equilibrium.



$W = 90\,kg \times 9.8\,m/s^2 = 882\,N$

(10 points) $F_1 + F_2 - W = 0 \Rightarrow F_1 = W - F_2 = 882N - 265N = 617N.$ (5 points)

(15 points) $-W \times 1.5m + F_2 \times 5m = 0$

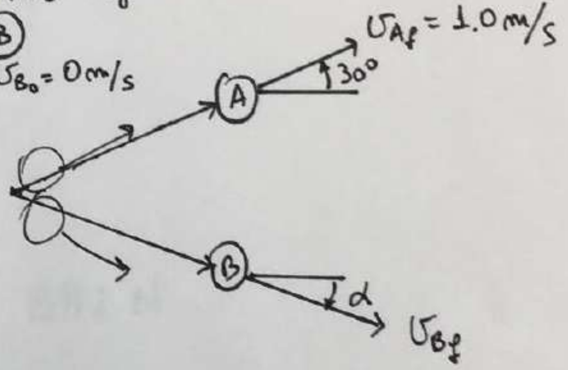
$F_2 = \frac{882N \times 1.5m}{5m} = 265\,N$ (5 points)

2. Linear Momentum (30 points)

The picture shows a collision between two pucks. Puck A has a mass of 5 kg and is moving along the x axis with a velocity of 2.0 m/s. It makes a collision with puck B, which has a mass of 3 kg and is initially at rest. The collision is not head-on. After the collision, the two pucks fly apart as shown in the figure. Puck (A) has a velocity of 1.0 m/s in the direction making an angle 30^o with the x-direction. What is the final velocity of puck B. Indicate its magnitude and direction given by the angle α as shown in the figure.

before collision : $m_A = 5\,kg$ (A)→ $v_{A_0} = 2.0\,m/s$ $m_B = 3\,kg$ (B) $v_{B_0} = 0\,m/s$

after collision :



$\hat{x}$: (10 points) $5\,kg \times 2\,m/s + 0 = 5\,kg \times 1.0\,m/s \times \cos 30^\circ + 3\,kg \times v_{Bfx}$

$\hat{y}$: (10 points) $0 = 5\,kg \times 1\,m/s \times \sin 30^\circ - 3\,kg\, v_{Bfy}$

(5 points)

$$v_{Bfy} = \frac{5\,kg \times 1\,m/s \times \sin 30^\circ}{3\,kg} = 0.8\,m/s$$

$$v_{Bfx} = \frac{10\,kg\,m/s - 5 \times \cos 30^\circ\,kg\,m/s}{3\,kg} = 1.9\,m/s$$

$$v_{Bf} = \sqrt{(0.8\,m/s)^2 + (1.9\,m/s)^2} = 2.1\,m/s$$

$$\alpha = \tan^{-1}\left(\frac{0.8}{1.9}\right) = 23^o$$

(5 points)

1. Energy (35 points).

A package is thrown from rest at point A down a curved ramp as shown in the figure. The package moves from Point A to B through a quarter-circle of radios $R = 4.0$m. The mass of the package is $m = 45$ kg. There is no friction in the circular ramp.

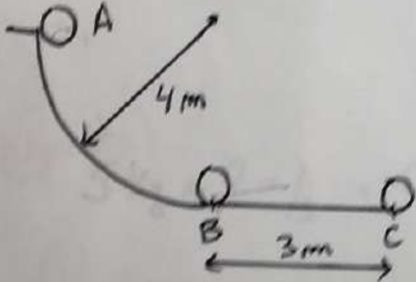
(a) (15 points) Find the speed of the package at point B.

(b) (10 points) The horizontal part has friction. If the block comes to rest at point C, what is the work of the friction force acting from B to C?

(c) (10 points) Consider now that the ramp from A to B has friction, and that the speed of the package at point B is $v_B = 6$m/s. What work was done by the friction force acting on the package from A to B?

(d) For extra credit: 5 points. Either you do it 100% correctly and you get full 3 points, or if you make a mistake you get 0 points. No partial credit, no discussions with grader about this problem. If your total score is above 100, then it is capped at 100.

Calculate the coefficient of friction from Part (b) considering that Point C is 3 m from Point B.



(a) $mg \times 4m = \frac{1}{2} m v_B^2$

$v_B = \sqrt{2 \times 9.8 m/s^2 \times 4m} = 8.8 m/s$

(b) $W_{NC} = W_{fric} = \Delta E$

$W_{fric}^{B \to C} = -\frac{1}{2} m v_B^2 = -\frac{1}{2} \times 45kg \times (8.8 m/s)^2 = -1742 J =$

$= -1.7 \times 10^3 J$

(c) $W_{fric}^{A \to B} = \Delta E = \frac{1}{2} m v_B^2 - mg \times 4m =$

with $v_B = 6 m/s$

$= \frac{1}{2} \times 45kg \times 36 m^2/s^2 - 45kg \times 9.8 m/s^2 \times 4m$

$= -954 J = -9.5 \times 10^2 J$

(d) $-f_k \times 3m = -1742 J$; $f_k = \mu_k \times F_N = \mu_k \times 45kg \times 9.8 m/s^2$

$\Rightarrow \mu_k = \frac{1742 J}{45kg \times 9.8 m/s^2 \times 3m} = 1.3$

1. Kinematics in 1D (30 points).

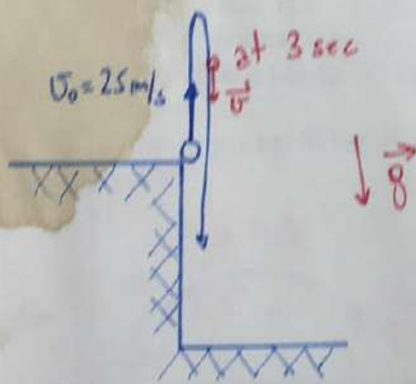
A ball is thrown vertically upward from the top of a building. The ball starts with an upward speed of 25 m/s at $t_0 = 0$. Find:

(a) [15 points] The maximum height reached as measured from the launching point and the time at which it is reached.

(b) [5 points] The position of the ball at $t = 2$ s.

(c) [5 points] The velocity of the ball at $t = 3$ s (magnitude and direction).

(d) [5 points] The acceleration of the ball at $t = 2.3$ s (magnitude and direction).



(a) $(25 m/s)^2 = 2 \times 9.8 m/s^2 \cdot H$

$H = \frac{(25 m/s)^2}{2 \times 9.8 m/s^2} = 31.9 m$

t_H: $0 = 25 m/s - 9.8 m/s^2 \cdot t_H$

$t_H = \frac{25 m/s}{9.8 m/s^2} = 2.5 s$

(b) $y(2s) = 25 m/s \times 2s - \frac{1}{2} \times 9.8 m/s^2 \cdot (2s)^2$

$= 30.4 m$

(c) $v(3s) = 25 m/s - 9.8 m/s^2 \cdot 3 s = -4.4 m/s$

direction pointing downward

magnitude = 4.4 m/s

(d) magnitude: $g = 9.8 m/s^2$

direction: downward

2. Kinematics in 2D. (30 points)

A soccer player hits a ball on the ground at an initial position $x_0 = 0$ m and $y_0 = 0$m. The ball leaves the ground with initial speed $v_0 = 20$m/s at an angle of 35^o with the horizontal.

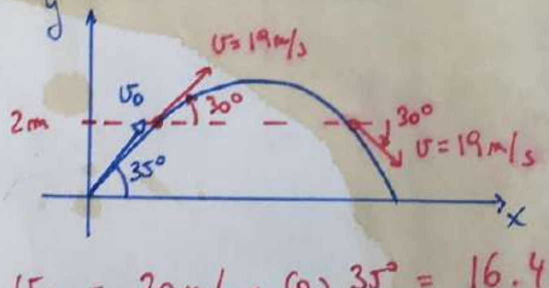
(a) [4 points] Find the position of the ball at $t = 2$s.

(b) [10 points] Find the time t_H when the ball reaches the highest point and find the maximum height H.

(c) [5 points] Find the time of flight and the horizontal range. That is, find the time and horizontal distance from the starting point to the point at which the ball hits the ground.

(d) [8 points] Find the velocities (in magnitude and direction) when the ball reaches a height of 2 m. Draw in the picture the vector velocities that you find.

(e) [3 points] What is the acceleration of the ball before just hitting the ground?



(e) $g = 9.8$ m/s² pointing downward

$v_{x_0} = 20$ m/s × cos 35° = 16.4 m/s

$v_{0y} = 20$ m/s × sin 35° = 11.5 m/s

(a) $x(2s) = 16.4$ m/s × 2s = 32.8 m

$y(2s) = 11.5$ m/s × 2s − ½ × 9.8 m/s² · 4s² = 3.4 m

(b) $-(11.5\ m/s)^2 = -2 \times 9.8\ m/s^2 \cdot H \Rightarrow H = 6.7$ m

$0 = 11.5\ m/s - 9.8\ m/s^2 \cdot t_H \Rightarrow t_H = 1.2$ s

(c) $t_R = 1.2s \times 2 = 2.4s$

$R = 16.4\ m/s \times 2.4s = 39.4$ m

(d) $v_y^2 - (11.5\ m/s)^2 = -2 \times 9.8\ m/s^2 \ 2\ m \Rightarrow v_y = \pm 9.6$ m/s

$v_x = 16.4$ m/s $\Rightarrow v = 19$ m/s, $\alpha_1 = 30°$, $\alpha_2 = -30°$

Two velocities: (see figure)
magnitude $v = 19$ m/s
direction 30° from horizontal (anticlockwise)

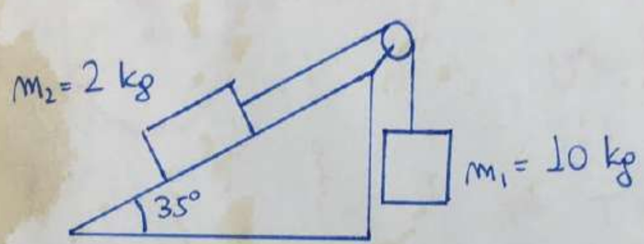
magnitude = 19 m/s
direction 30° from horizontal (clockwise)

3. Newton's laws of motion. (30 points)

Two blocks with mass $m_1 = 10$ kg and $m_2 = 2$ kg are connected by a string. The incline surface has an angle of 35^0. See figure. The inclined surface and the pulley are frictionless.

(a) [25 points] Find the direction and magnitude of the hanging block's acceleration. Determine the direction of motion.

(b) [5 points] Determine how much mass you have to add to m_2 so that the blocks do not move.



(a) $$a = g\left(\frac{m_1 - m_2 \sin 35°}{m_1 + m_2}\right) = 7.2\ m/s^2$$

(b) we need a new m_2' such that : $a = 0$

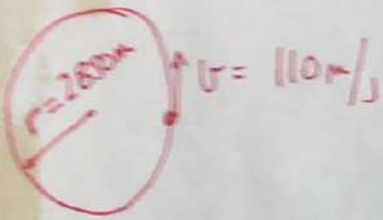
$$m_1 - m_2' \sin 35° = 0$$

$$m_2' = \frac{m_1}{\sin 35°} = \frac{10\ kg}{\sin 35°} = 17.4\ kg$$

$\Rightarrow$ we need to add $17.4\ kg - 2\ kg = 15.4\ kg$ to m_2

4. Uniform circular motion (10 points)

How long does it take a plane, traveling at a constant speed of 110 m/s, to fly once around a circle whose radius is 2850 m?



$$v = \frac{2\pi r}{T}$$

$$\Rightarrow T = \frac{2 \times \pi \times r}{v} = \frac{2 \times 3.14 \times 2850\,m}{110\,m/s} = 163 \text{ sec}$$