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Midterm 1 Exam
Physics 1A, Winter 2013
Wednesday, April 24, 2013

READ THE FOLLOWING CAREFULLY:

- Do not open the exam until instructed to do so. Please use pencil. This exam is closed book. You may use a calculator and one cheat sheet consisting of a full sheet of paper (both sides). Please remove and turn off all other electronic devices.
- This exam consists of 7 pages (including this one) with problems numbered 1 through 3; make sure you have been given all pages/problems.
- You will have 50 minutes to complete this exam. Do all problems. Show all work and reasoning, including diagrams where appropriate. You will not receive credit for answers that have no justification. You may continue your work on the back of a page, or on extra paper, which you can staple to the back of the exam. In such cases, be sure to indicate, using arrows or brief explanations (e.g., "see back", or "see attached paper"), where the rest of your answer is located.
- You must show a photo ID when turning in your exam.
- **Regrades:** When the exams are returned, you'll be told who graded which problem. For exam problems graded by the TA, contact the TA directly. For exam problems not graded by the TA, please visit me during office hours, or contact me to arrange an appointment. Do not write on your exam after it is returned to you, as this will negate your chances for a regrade. Note that a fraction of the graded exams will be photocopied prior to returning them to you.

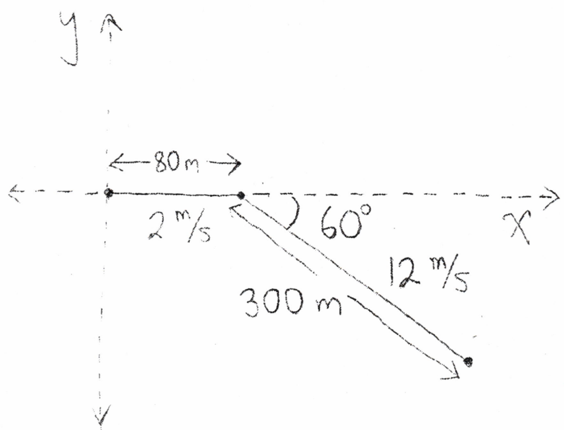
1	24	23
2	38	38
3	38	38
Total	100	99

Useful constants:

$g = 9.8 \text{ m/s}^2$

23

1. (24 pts) Starting from her house, Debbie walks her bike 80 m east at a constant speed of 2 m/s. Wasting no time, she then immediately climbs onto her bike and rides it at a constant speed of 12 m/s for 300 m along a path directed 60 deg south of east. For this entire trip, what are Debbie's (i) average speed and (ii) average velocity? Define the positive x-direction as east and the positive y-direction as north.



Average speed = total distance travelled / total time

$= \dfrac{80\,m + 300\,m}{\text{time for part 1} + \text{time for part 2}}$

$= \dfrac{380m}{\left(\frac{80m}{2\,m/s}\right) + \left(\frac{300m}{12\,m/s}\right)}$

speed ≈ 5.846 m/s

Average velocity = total displacement / total time

$\vec{v}_1 = \langle 80, 0 \rangle$

math :-(

$\vec{v}_2 = \langle 300\cos(-60°), 300\sin(-60°) \rangle$

$\vec{w} = \vec{v}_1 + \vec{v}_2 = \langle 80 + 300\cos(-60°), 300\sin(-60°) \rangle$

230 -259.81

$|\vec{w}| = \sqrt{\vec{w}_x^2 + \vec{w}_y^2} \approx 346.99\,m$ $\theta = \tan^{-1}\left(\frac{w_y}{w_x}\right) = -48.48°$

$\dfrac{|\vec{w}|}{\left(\frac{80m}{2\,m/s}\right) + \left(\frac{300m}{12\,m/s}\right)} = 8.1644\,\frac{m}{s}$

velocity = 8.1644 m/s, 48.48° south of east.

2. (38 pts) Inside an elevator which is initially at rest, you kick a soccer ball which leaves the floor at 6 m/s directed upward and to the right at 40 deg above the horizontal.

   (a) What maximum height does the soccer ball reach above the stationary elevator floor?

   (b) At the instant the soccer ball reaches its maximum height, the elevator begins to accelerate upward from rest at a constant rate of 5 m/s^2. What total horizontal distance does the ball travel from where it was kicked to where it returns to the elevator floor?

   (c) When the soccer ball returns to the elevator floor, what are the horizontal and vertical components of its velocity **with respect to** the floor?

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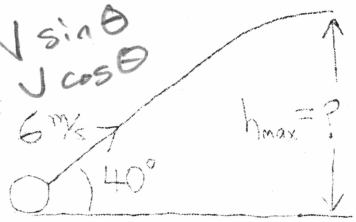
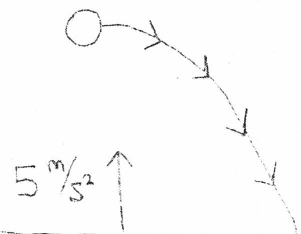
$V_{iy} = V\sin\theta$

$V_{ix} = V\cos\theta$





$V_{fy}^2 = V_{iy}^2 + 2a\Delta y$

$\frac{V_{fy}^2 - V_{iy}^2}{2a} = \Delta y$

$\frac{0^2 - (V\sin\theta)^2}{2g} = \Delta y$

$\frac{-(6\sin 40°)^2}{2(-9.8)} = \Delta y$

$\boxed{\Delta y = .7588 \text{ m}}$

$a_e = 5 \text{ m/s}^2$

$|a_b| = |-9.8 \text{ m/s}^2|$

$\Delta d = v_i t + \frac{1}{2}at^2$

$\Delta d_b + \Delta d_e = .7588 \text{m}$

$\frac{1}{2}(9.8)t^2 + \frac{1}{2}(5)t^2 = .7588\text{m}$

$4.9t^2 + 2.5t^2 = .7588\text{m}$

$t_{second\ half} = .3202195193\text{s}$

$.7588 = 6\sin 40° t - 4.9t^2$

$4.9t^2 - 6\sin 40° t + .7588 = 0$

$t_{first\ half} = .3935434345\text{s}$

$t_{total} = .7137629538$

$\Delta x = v_{ix}t + \frac{1}{2}at^2$

$\Delta x = V\cos\theta\, t_{total}$

$= 6\cos 40° (.7137629538)$

$\boxed{\Delta x = 3.280644867 \text{ m}}$

with respect to floor,

$V_{x_b} = V\cos\theta$ since $V_{xe} = 0$

$\boxed{V_{x_{rel}} = 4.596 \frac{m}{s} \text{ right}}$

at $t_{second\ half} = .3202195193\text{s}$,

$\Delta y_e = V_{iy}t + \frac{1}{2}at^2$

$= 0 + \frac{1}{2}(5)t^2$

$\Delta y_e = .2563513514 \text{ m}$

$V_{fe}^2 = V_{ie}^2 + 2a\Delta y_e$

$V_{fe} = \sqrt{2a\Delta y_e}$

$= 1.661097597 \text{ m/s}$

$\Delta y_b = .7588\text{m} - \Delta y_e$

$V_{fb} = \sqrt{2a\Delta y_b}$

$= 3.128768 69 \text{ m/s}$

$V_{relative} = -V_{fb} - V_{fe}$

$V_{relative} = -4.731 \text{ m/s}$

$\boxed{V_{y_{rel}} = 4.731 \frac{m}{s} \text{ down}}$

Check

$F_b - m_b a = m_c a - F_c$

$\frac{F_b + F_c}{m_c + m_b} = a$

$F_b - m_b a = T$

$m_c a - F_c = T$

$F_b - T = m_b a$

$F_c + T = m_c a$

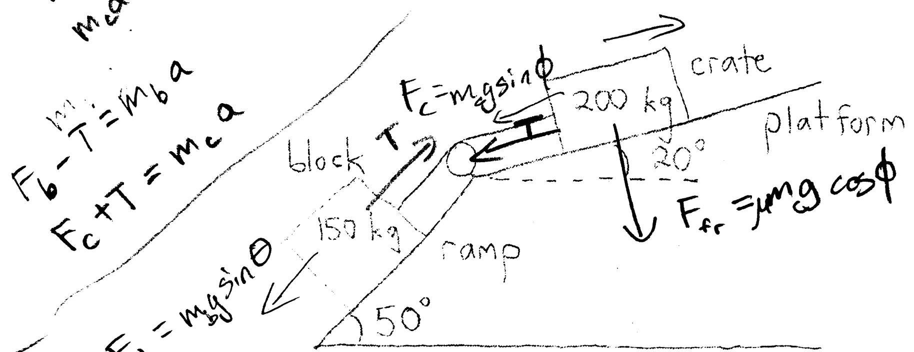
3. (38 pts) A ramp slopes upward and to the right at 50 deg above the horizontal, and is joined at the top to a platform inclined upward and to the right at 20 deg above the horizontal. A 150-kg block rests on the ramp, and is connected by a light string passing over a light, frictionless pulley, to a 200-kg crate which rests on the platform. The system is initially held in place, and then released from rest.

(a) At what rate do the block and crate accelerate? Assume the system is frictionless.

(b) Now suppose the platform has friction, though the ramp is still frictionless. What must be the minimum coefficient of static friction between the crate and platform in order for the system to remain at rest when released?

$\theta = 50°$ $\quad m_b = 150kg$

$\phi = 20°$ $\quad m_c = 200kg$



$F_b = m_b g \sin\theta$
$= 150(9.8)\sin 50°$
$= 1126.085331$ N

$F_c = m_c g \sin\phi$
$= 200(9.8)\sin 20°$
$= 670.3594809$

$(\Sigma F) = (m_{system})(a_{system})$

$F_b + F_c = (m_b + m_c) a_{system}$

$\frac{F_b + F_c}{m_b + m_c} = a_{system}$

$a_{system} = 5.132699463 \ m/s^2$

$F_{fr} = F_b + F_c$

$\mu m_c g \cos\phi = m_c g \sin\phi + m_b g \sin\theta$

$\mu = \frac{m_c g \sin\phi + m_b g \sin\theta}{m_c g \cos\phi}$

$\mu = \frac{m_c \sin\phi + m_b \sin\theta}{m_c \cos\phi}$

$\mu = .9753758361$