Evan Snyder
504 907 430

Physics 1A
Spring 2018

Midterm Exam 2

Friday, May 25, 2018
16:00 – 16:50, PAB 1-725

1	10
2	6
3	8

READ THIS BEFORE YOU BEGIN

1. You are allowed to use only yourself and a writing instrument on the exam.
2. Print your name on the top right of your exam.
3. If you finish more than 5 minutes before the end of the exam period, then please raise your hand and a proctor will collect your exam. Otherwise, please stay in your seat until the end of time is called.
4. When the exam is finished, please remain in your seat, and the proctor(s) will come around and collect your exam. Once your exam is collected, you may leave the room.
5. Show all work. The purpose of this exam is primarily to test how you think; you will get more partial credit for a logical, well-thought-out response.
6. Please box all of your final answers to computational problems.

ADVICE

Do not just attempt to blindly calculate answers to computational questions. Use your physical and geometric intuition first to try and determine as much about the answer as you can before you launch into computation!

Problem 1

A train moves along the tracks at a constant speed u. A woman on the train throws a ball of mass m straight ahead with a speed v with respect to herself. (a) What is the kinetic energy gain of the ball as measured by a person on the train? (b) by a person standing by the railroad track? (c) How much work is done by the woman throwing the ball and (d) by the train?

a) $\boxed{\frac{1}{2}mv^2}$ w.r.t. person on train, $\Delta v_{ball} = v - 0$, so

$\Delta K = \frac{1}{2}m(\Delta v)^2 - \frac{1}{2}m \cdot 0$
$= \frac{1}{2}mv^2$

3 3 $\frac{1}{2}m(u^2+2uv+v^2)$

b) $\boxed{\frac{1}{2}m(u+v)^2 - \frac{1}{2}mu^2 \text{ (or } \frac{1}{2}mv^2+muv)}$ on ground, ball on train has $v_i = u$,

$v_f = u+v$, so $\Delta K = \frac{1}{2}m(v+u)^2 - \frac{1}{2}mu^2$

c) $\boxed{\frac{1}{2}mv^2}$ work $= \Delta K$, by work-kin. energy thrm., w.r.t. to train, woman does all work,

so $W_{woman} = \Delta K_{w.r.t.\ train}$

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d) $\frac{1}{2}m(\cancel{u^2}+\cancel{2}uv+\cancel{v^2}) - \cancel{\frac{1}{2}mu^2} - \cancel{\frac{1}{2}mv^2}$

$= \boxed{muv}$ 2

w.r.t. to ground state, $\Delta K = \frac{1}{2}m(u+v)^2 - \frac{1}{2}mu^2$,

work done by woman is $\frac{1}{2}mv^2$, so this can be subtracted to obtain work from train,

$\frac{1}{2}mv^2 - \frac{1}{2}mv^2 + \frac{1}{2}mu^2 - \frac{1}{2}mu^2 + \frac{1}{2}m(2uv)$

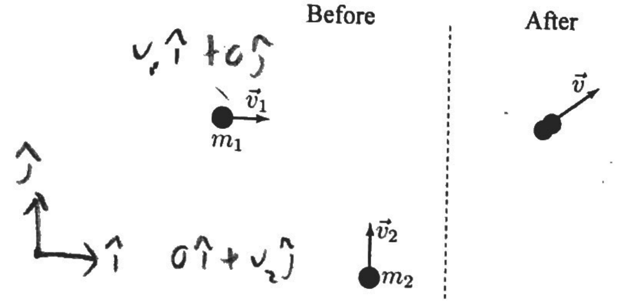
$= muv$

+10

Problem 2

+10

Suppose that two particles of mass m_1 and m_2 are moving with velocity $\vec{v}_1$ and $\vec{v}_2$ in two-dimensions as shown in the figure below. After they collide, they stick together. Find the final velocity of the two particles after the collision.



by cons. of momentum (no external forces)

$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1+m_2)\vec{v}$$

$$m_1(v_1\hat{i}+0\hat{j}) + m_2(0\hat{i}+v_2\hat{j}) = (m_1+m_2)\vec{v}$$

$$m_1v_1\hat{i} + m_2v_2\hat{j} = (m_1+m_2)\vec{v}$$

$$\boxed{\vec{v} = \frac{m_1}{m_1+m_2}v_1\hat{i} + \frac{m_2}{m_1+m_2}v_2\hat{j}}$$

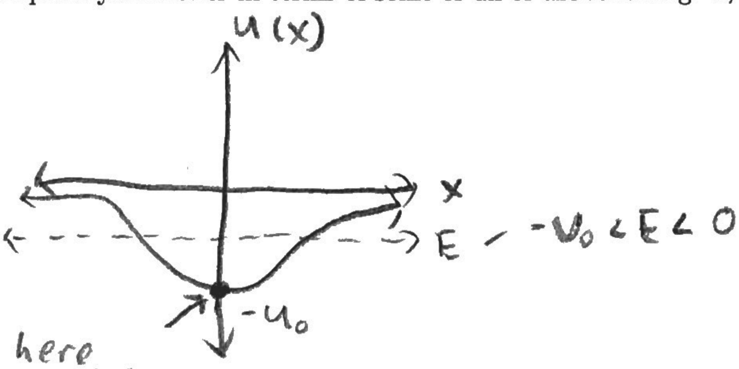
Problem 3

A particle of mass m moves in one dimension. Its potential energy is given by

$$U(x) = -U_0 e^{-x^2/a^2}$$

where U_0 and a are constants. (a) Draw an energy diagram showing the potential energy $U(x)$. Choose some value for the total mechanical energy E such that $-U_0 < E < 0$. Mark the kinetic energy, the potential energy and the total energy for the particle at some point of your choosing. (b) Find the force on the particle as a function of position x. Express your answer in terms of some or all of the following: x, a, and U_0. (c) Find the speed at the origin $x = 0$ such that when the particle reaches $x = \pm a$, it stops momentarily and reverses the direction of its motion. Express you answer in terms of some or all of the following: x, a, m and U_0.

a)



here, $K = E + u_0$, $u = -u_0$, $E_{tot} = E$

b) $F(x) = \frac{d}{dx}(u(x)) = \frac{d}{dx}\left(-u_0 e^{-x^2/a^2}\right)$

$$\boxed{F(x) = \frac{2x}{a^2} u_0 e^{-x^2/a^2}}$$

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c) when $x = \pm a$, $u(x) = -U_0 e^{-1} = E_{tot}$ b/c particle is at rest.

K

when $x = 0$, $U(x) = -U_0$, $E_{tot} = -U_0 + \frac{1}{2} m v^2 = -U_0 e^{-1}$

$$\boxed{v = \sqrt{\frac{2}{m}\left(-U_0 - U_0 e^{-1}\right)}}$$