Physics 110 – Spring 2014
Hour Exam #2

Name:____Solutions__________________________________

I affirm that I have carried out my academic endeavors with full academic honesty.

*Signed:*____

Short answers (2.5 pts each for a total of 25 pts): **Answer all questions with only one response in the margin. Note that some of these will require short calculations on your part.**

_______C______1. A yo-yo of mass M is spun "around the world" in a vertical loop-the-loop of radius R at a constant speed v. What is the centripetal force on the yo-yo at the top of its trajectory where the tension in the string is T?
a) Mg – T b) T – Mg c) T + Mg d) T + Mg + Mv^2/R e) none of these

_______E______2. Two identical blocks of mass m are tied together by a light cord and pulled up a rough inclined plane at a constant speed by a pulling force F directed along the incline and applied to the upper block. Which of the following statements is true? (Hint: it should help to draw free-body diagrams.)
a) The work done by F is zero since the blocks move at constant speed.
b) The total friction force must equal F since the blocks move at constant speed.
c) The tension in the cord is F because the two blocks are identical.
d) The work done by F is equal in magnitude to the work done by friction.
e) None of the above is true.

_______D______3. A 0.1 kg meter stick has two masses attached: 0.2 kg at 30 cm and 0.5 kg at 100 cm. The center of mass of the system (3 masses!!) lies at (in cm)
a) 80 b) 70 c) 87.1 d) 76.3 e) None of these

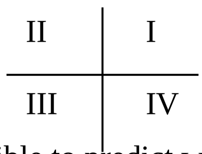
_______A______4. Two blocks make a head-on collision on a frictionless horizontal surface. If the 3 kg block was traveling to the right at 10 m/s and the 5 kg block was traveling to the left at 6 m/s, what is their common final speed (in m/s) if they stick together after the collision?
a) 0 b) 7.5 c) 3.8 d) 4 e) None of these

_______C______5. In a short time Δt of a collision between a car of mass M traveling at speed V and a soccer ball of mass m, initially at rest, the soccer ball is given a large velocity v. The magnitude of the average force on *the truck* is
a) 0 b) Mv/Δt c) mv/Δt d) (MV-mv)/Δt e) None of these

_______C______6. A cart slides on a loop-the-loop track from a height of 8R where R is the radius of the loop-the-loop. The velocity of the cart at the top of the loop-the-loop is given by
a) $\sqrt{gR}$ b) $\sqrt{6gR}$ c) $\sqrt{12gR}$ d) $\sqrt{3gR}$ e) None of these

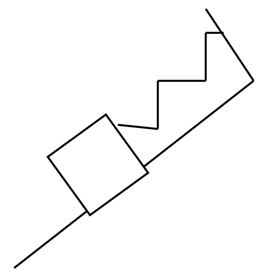
_______A______7. As an object is spun in circular motion with an increasing speed, the forces on the object are directed
a. radially inward and tangentially along the velocity
b. radially outward and tangentially along the velocity
c. radially inward
d. radially inward and tangentially opposite to the velocity
e. None of the above

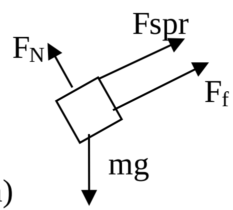
______B_____8. A fireworks rocket is shot vertically upward and explodes at the top of its trajectory into three equal parts. If one part falls vertically down with velocity V and one is shot at a 45^{o} angle above the positive horizontal direction with velocity V, the third piece must have its momentum point in quadrant



a) I
b) II
c) III
d) IV
e) It is impossible to predict with the given information.

_____B______9. A block sits on a rough inclined plane, attached to a spring oriented along the plane as shown on the right. If the block oscillates back and forth along the inclined plane, the free body diagram for the block, while moving up the plane towards the equilibrium is



a)


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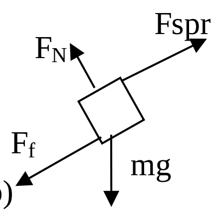

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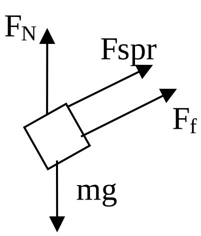
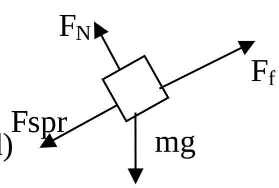


d)


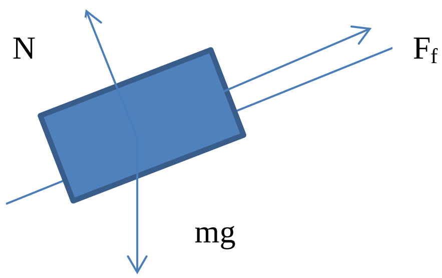
e) None of these

______C_____10. You are pushing a wooden crate across the floor at constant speed. You decide to turn the crate on end, reducing by half the surface area in contact with the floor. In the new orientation, to push the same crate across the same floor with the same speed, the force that you apply must be about
a) four times as great
b) twice as great
c) equally great
d) half was great
e) one-fourth as great
as the force required before you changed the crate's orientation.

Problems: **Answer all parts and show all work for full credit.**

1. (30 pts) A 5 kg block slides down a 30^o rough inclined plane with a coefficient of kinetic friction of 0.2.

a) Draw a free body diagram of the block.



b. Write down the equations of motion, *assuming the block moves*, and find its acceleration down the plane.

$mg \sin30 - \mu_k N = ma$

$N - mg \cos30 = 0$

So $mg \sin30 - \mu_k mg \cos30 = ma$ giving $a = 3.2\ m/s^2$

c. Find the velocity of the block after sliding 2 m down along the inclined plane starting from rest.

Using $v^2 = 0 + 2\ a\ \Delta x$, we find v = 3.58 m/s

d) Solve part c) over again using the Work-Energy Theorem (or if you used this in part c already, re-solve that part using kinematics)

$W_{net} = \Delta KE = KE_f - 0 = ½\ mv^2$

But $W_{net} = mg \sin30\ (2) - \mu_k\ mg \cos30\ (2) = ½\ mv^2$

Resulting in v = 3.58 m/s agreeing with part b.

e) If the inclined plane sits at the top edge of a 10 m tall building, find the velocity (horizontal and vertical components) with which the block hits the ground after sliding down the incline and free-falling to the ground.

As the block leaves the incline it has the velocity found in part c or d directed at an angle of 30 below the horizontal.

$v_x = v \cos30 = 3.1$ m/s and stays constant

while v_y is found from $v_y^2 = v_{oy}^2 = 2\ g\ (10)$ giving $v_y = 14.1$ m/s down

2. (24 pts) Two pucks are sliding on ice towards each other. One puck has a mass of 2 kg and is traveling at 10 m/s to the right and the other has a mass of 2.5 kg and is traveling in the opposite direction at a speed of 8 m/s. At time zero the pucks are 10 m apart.

a) Find the location of the center of mass of the two pucks at time zero. Use the puck on the left as your origin of coordinates.

With the origin on the left puck at time zero, as suggested,
$X_{cm} = (0 + 2.5(10))/(2 + 2.5) = 5.56$ m

b) Find the time at which the two pucks will collide and show that they will collide at the center of mass.

For the left puck to travel 5.56 m requires a time of $t = 5.56/10 = 0.556$ s
In this time the left puck moves $x = vt = 5.56$ m to arrive at the cm
In this same time the right puck moves a distance of $x = (8)(0.556) = 4.44$ m also arriving at the cm,
Since the cm is a distance of (10 m – 5.56 m) = 4.44 m to the left of the right puck at time zero.

c) If the two pucks stick together after the collision, which lasts a time of 0.005 seconds, find their final velocity and find the magnitude of the average force exerted on each puck.

Conservation of momentum gives:

$p_i = 2(10) - 8(2.5) = 0$ and so if this equals p_f, the $v_f = 0$.

Also, the average force on the left puck is $\langle F_1 \rangle = \Delta p_1/\Delta t = (0-20)/0.005 = -4000$ N

Similarly, the average force on the right puck is $\langle F_2 \rangle = \Delta p_2/\Delta t = (0 - (-20))/0.005 = +4000$ N

Giving equal and opposite forces as there must be.

d) Was energy conserved in the collision? If yes, find the constant energy; if not, find the fraction of energy lost. Show work.

No since all the KE is lost (they stop) – so 100% of the KE is lost.

3. (21 pts) In an amusement park ride, people stand against the outer wall of a large spinning drum and after the drum rotates beyond a certain speed, the floor falls away, leaving the people suspended against the wall.

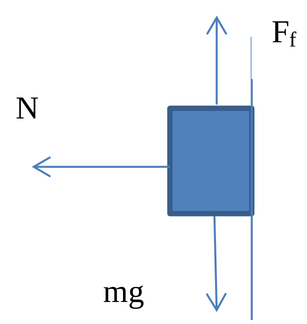
a) If the drum starts from rest and accelerates at a constant rate up to an angular speed of 15 rpm in 30 seconds, find the angular acceleration in rad/s^2.

Using $\omega = \omega_o + \alpha t$
with the initial angular velocity = 0, t = 30 s, and converting the final angular velocity to rad/s,
we find $\alpha = 0.052$ rad/s^2

b) If the radius of the drum is 12 m, find the resulting speed (in m/s) at the end of the 30 second interval of a person against the outer wall spinning in the drum.

$v = \omega R = 18.8$ m/s

c) If the coefficients of static and kinetic friction are 0.4 and 0.2, respectively, will the people remain suspended against the outer wall when the floor falls away at the end of the 30 seconds? Show all work justifying your answer.



To stay in place the friction force must balance mg
But $N = mv^2/R$ and so $F_f \leq \mu_s N$ means that
We require
$\mu_s mv^2/R \geq mg$,
Putting in the numbers we see that for this to be the case we require the velocity $v \geq 17.1$ m/s, but this is the case and so the people will remain in place. The maximum friction force being greater than mg does not cause the people to levitate, it just means that the static friction is actually less than the maximum value and just balances mg.