Print name______________________________

ID number______________________________

Section in which you are registered (sec 1 = 9 AM lec, sec 2 = 10 AM lec)__________

# Physics 142E, Test No. 1, test session 2

# February 18, 2004, 7:30-9:00 PM

**On the bubble sheet, fill in your student id number, and in addition write your name and your section in the appropriate spot**. After you have found an answer, fill in the appropriate bubbles on your bubble sheet—note any special instructions on this point in the problem itself. The last problem is a multipart problem whose solution should be written out neatly. You can get partial credit for this problem, so make sure that your answers are written out and contain no ambiguities.

No notes or books are allowed during the exam, nor is any consultation with anyone but me. You should be taking the 5:30 exam if you are in section 1 (9 AM lecture) and the 7:30 exam if you are in section 2 (10 AM lecture).

Write out an authorized form of the pledge here, and sign it.

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Signed__________________________

formulas you might need: $\frac{d}{dx}x^n = nx^{n-1}; \int x^n dx = \frac{x^{n+1}}{n+1}$

$v(t) \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$ ; $a \equiv \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$

$\vec{v} = \vec{v}_0 + \vec{a}t$ ; $\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$ ; $v^2 = v_0{}^2 + 2a(x - x_0)$

$\vec{a} = -\frac{v^2}{r}\hat{r}$

$\vec{F}_{net} = m\vec{a}$

$\vec{F}_{BA} = -\vec{F}_{AB}$

$\vec{F}_g = m\vec{g}$

$0 \le f_s \le \mu_s F_N; f_k = \mu_k F_N$

$W_{net} \equiv F_{net}\Delta x;\ W = \lim_{\Delta \vec{r} \to 0} \sum \vec{F} \cdot \Delta \vec{r} = \int_{\vec{r}_A}^{\vec{r}_B} \vec{F} \cdot d\vec{r}$ .

$K \equiv \frac{1}{2}mv^2$

$W_{net} = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = \Delta K$

$P \equiv \frac{dW}{dt}$.

1. (10 points) A bicycle tire is 75 cm in diameter. If the wheel spins at a steady 265 rev/min, what is the magnitude of the acceleration of a point on the rim?

(a) 12 $m/s^2$

*(b) 289 $m/s^2$

(c) 221 $m/s^2$

(d) 86 $m/min^2$

(e) there is no acceleration of a rim point

2. (10 points) The coefficient of kinetic (sliding) friction for waxed skis on a certain type of snow is $\mu_k$ = 0.05. For what angle ski slope is a moving skier's acceleration zero? (Measure the angle from the horizontal.)

(a) 0.1 rad

*(b) 3°

(c) 0.2 rad

(d) 5°

If you set up axes so that the x-axis is laong the slope, with positive to the bottom, and the y-axis perp to the slope, with up positive, then the forces are friction = $\mu_k N$ to neg x, N to pos y, and mg vertically down, with x and y comps mgsinθ and mgcosθ, respectively. The motion eqs for no accel are

x: $-\mu_k N + mg\sin\theta = 0$

y: $N - mg\cos\theta = 0$

The y eq allows us to set N = mgcosθ, and plugged into the first we find $-\mu k\ mg\cos\theta + mg\sin\theta = 0$, or $\sin\theta/\cos\theta$ (= tanθ) = $\mu_k$ = 0.05, or. This gives θ = 2.9°.

3. (10 points) Newton's second law states that for a given force the acceleration of an object is inversely proportional to its mass—the greater the mass, the smaller the acceleration. Yet it is also a fact that if air resistance is ignored, all objects in the vicinity of Earth's surface accelerate under the force of gravity in the same way, whatever their mass. This is because:

(a) Newton's second law does not apply to the case of gravity.

*(b) The force of gravity is proportional to the inertial mass of the object it acts on.

(c) The force of gravity is proportional to the square of the inertial mass of the object it acts on.

(d) If Earth causes an object to accelerate, Earth itself must accelerate to the object.

4. (10 points) You place a steak on a flat horizontal plate and slide the plate across a horizontal table. Is the force of friction due to the plate acting on the steak doing positive or negative work on the steak?

*(a) Positive work

(b) Negative work

Imagine you start walking to the right. Without friction, the steak would, from the point of view of someone moving with the plate, slide off to the left. Thus friction must here be acting to the right (opposite to the direction the mass would move if there were no friction), in the *same* direction as the displacement.

5. (10 points) What is the work required to accelerate a 1825 kg car from rest to a speed of 27 m/s?

(a) 318 W

*(b) 665 kJ

(c) 3.82 J

(d) 665 kW

(e) 382 J

According to the work-energy theorem, the nec work is equal to the change in kinetic energy, which here is $\frac{1}{2}mv^2 = \frac{1}{2}(1825\text{ kg})(27\text{ m/s})^2 = 6.65 \times 10^5$ J.

6. (10 points) Two small heavy balls of the same size leave the edge of a horizontal table top in the University's rotunda at the same moment. There is a level horizontal floor 75 cm below. The orange ball drops straight down to the floor, while the green ball leaves the edge moving horizontally at a speed of 15 cm/s. Only one of the following statements is true—which one? (Ignore any effect due to air resistance.)

(a) The orange ball hits the floor before the green ball does.

(b) The green ball hits the floor before the orange ball does.

*(c) Both balls strike the floor at the same time.

(d) Neither (a) nor (b) nor (c) is true.

7. (10 points) An amateur football player punts a football straight up with an initial speed of 15 m/s. Assume that the acceleration due to gravity is 10 $m/s^2$ and ignore all effects of air resistance. How long is the football in the air?

(a) 1 s

(b) 2 s

*(c) 3 s

(d) 8 s

The motion is that of constant accel, namely $a = -g$, where we have set the positive direction upward: $y = y_0 + v_0 t - \frac{1}{2} g t^2$ . If ground level is $y = 0$, then $y_0 = 0$, and we are given $v_0 = +15$ m/s. We want to know when $y = 0$, i.e., find the times for which

$$0 = v_0 t - \tfrac{1}{2} g t^2.$$

This eq has soln $t = 0$ (just the time at which the kick starts) and $t = 2v_0/g$. The latter is the landing time, what we want. Numerically it gives $t = 2\ (15\ \text{m/s})/(10\ \text{m/s}^2) = 3$ s.

for fig, see the exam itself. 8. (30 points) An object of mass *m* attached to the end of an ideal (massless and unstretchable) string of length *R* moves in a circle of radius *R*; the circle lies in a vertical plane as in the figure. Neglect any effects due to air resistance.

Note that the geometry guarantees that the motion is circular, but it is not uniform cicular motion so that the force is not always centripetal. When it is we can match the force to the centripetal accel of magnitude $v^2/R$.

(a) (5 points) What are the forces acting on the object?

The tension of the string and gravity.

(b) (5 points) Draw a free body diagram for the object appropriate to each of the four labelled points A – D.

I can't draw this here – the main point I wanted to see is T varying in its direction, each time leading to the center of the circle, while gravity is always down.

(c) (5 points) The string is taut almost all the way around its path, just barely going slack at the top of the circle (point B). What is the speed $v_B$ of the object at that point? (I expect an algebraic answer in the form $v_B = \ldots$)

At the top, the tension is zero, and the only force acting at gravity. But at that point gravity does point back to the center of the circle, so that

$$F_g = mg = mv_B^2/R.$$

Solve this for vB: $v_B = \sqrt{gR}$ .

(d) (5 points) As the object subsequently moves from point B to point D, what is the work done on it by (i) the tension in the string and (ii) gravity?

(i) Tension does no work, because it is always perp to the displacement here.

(ii) Gravity does work that is independent of the path and depends on the vertical displacement, here 2R downward. Gravity is also downward, so the work it does is positive. Since gravity has a constat value, the work is just the force times the displacement, $W_g = mg(2R) = 2mgR$.

(e) (5 points) Use the results of part (d) to figure the speed $v_D$ of the object at point D given the particular value $v_B$ that you found in part (c). (You can get partial credit if you just suppose there is some general value $v_B$ at point B and work from there.)

The net work is the change in kinetic energy by the work-energy theorem:

$$W_{net} = W_g = \tfrac{1}{2} m v_D^2 - \tfrac{1}{2} m v_B^2, \text{ or } v_D = \sqrt{\frac{2}{m}\left(W_g + \frac{1}{2}mv_B^2\right)} = \sqrt{\frac{2}{m}\left(2mgR + \frac{1}{2}mv_B^2\right)}.$$

If we use the value of $V_B$ from part (c) we have $v_D = \sqrt{\frac{2}{m}\left(2mgR + \frac{1}{2}mgR\right)} = \sqrt{5gR}$

(f) (5 points) What is the tension in the string at point D given the particular value of $v_D$ that you found in part (e)? (You can get partial credit if you just suppose there is some general value $v_D$ at point D and work from there.)

At the bottom of the swing, all forces are again lined up with the center point. With up positive, we match the net force to the mass times the (centripetal) accel:

$$T - mg = mv_D^2/R, \text{ or } T = m(g + v_D^2/R).$$

Using $v_D$ from part (e),

$$T = m(g + 5gR/R) = 6mg.$$