Physics 121, Midterm Exam #1

Tuesday February 28, 2008

8.00 am – 9.30 am

Do not turn the pages of the exam until you are instructed to do so.

You are responsible for reading the following rules carefully before beginning.

Exam rules: You may use *only* a writing instrument while taking this test. You may *not* consult any calculators, computers, books, nor each other.

Answer the multiple-choice questions (problems 1 – 10) by marking your answer on the attached pages. For each multiple-choice question (problems 1 – 10), select only one answer. Questions with more than one answer selected will be considered incorrect. Problems 11, 12, and 13 must be answered in the blue exam booklets and need to be well motivated and expressed in terms of the variables used in the problem. **Answer questions 11 and 12 in booklet # 1 and question 13 in booklet # 2.** You will receive partial credit where appropriate, but only when we can read your solution. Answers that are not motivated will not receive any credit, even if correct.

At the end of the exam, you need to hand in your exam, the blue exam booklets, and your scantron form. All items must be clearly labeled with your name and student ID number. If any of these items is missing, we will not grade your exam, and you will receive a score of 0 points.

Name: _____

ID number: _____

Workshop Day/Time: _____

Useful Relations:

$$\cos(30°)=\frac{1}{2}\sqrt{3} \quad \sin(30°)=\frac{1}{2} \qquad \tan(30°)=\frac{1}{3}\sqrt{3}$$

$$\cos(45°)=\frac{1}{2}\sqrt{2} \quad \sin(45°)=\frac{1}{2}\sqrt{2} \quad \tan(45°)=1$$

$$\cos(60°)=\frac{1}{2} \qquad \sin(60°)=\frac{1}{2}\sqrt{3} \quad \tan(60°)=\sqrt{3}$$

$$\cos\left(\frac{1}{2}\pi-\theta\right)=\sin(\theta) \qquad \sin\left(\frac{1}{2}\pi-\theta\right)=\cos(\theta)$$

$$\cos(2\theta)=1-2\sin^2(\theta) \qquad \sin(2\theta)=2\sin(\theta)\cos(\theta)$$

	circle	sphere
circumference	$2\pi r$	
(surface) area	πr^2	$4\pi r^2$
volume		$\frac{4}{3}\pi r^3$

Problem 1 (2.5 points)

A planet has the same mass as the Earth, but its surface gravitational acceleration is $g/2$. What is the radius of the planet?

1. $2 \times r_E$
2. $\sqrt{2} \times r_E$
3. $4 \times r_E$
4. $r_E/2$

Problem 2 (2.5 points)

At which point is the gravitational force zero between two masses separated by a distance d when one mass has a mass m and the other has a mass $4m$?

1. (1/3) d away from the mass m
2. (1/3) d away from the mass $4m$
3. (1/4) d away from the mass m
4. (1/4) d away from the mass $4m$

Problem 3 (2.5 points)

A satellite is in a circular orbit of radius r about a planet of mass m. Its orbital period is T. What is the period of an orbit with the same radius r about a planet of mass $2m$?

1. $2T$
2. $T/2$
3. $T/\sqrt{2}$
4. $T/4$

Problem 4 (2.5 points)

Three projectiles A, B, and C are launched with the same initial velocities at angles of 30°, 45°, and 60°, respectively. Their launch position and their points of impact are located at sea level. What is the relation between their flight times?

1. $t_A = t_C > t_B$
2. $t_B > t_A = t_C$
3. $t_A > t_B > t_C$
4. $t_C > t_B > t_A$

Problem 5 (2.5 points)

Observer B is moving with a constant velocity relative to observer A. Observer A sees an object accelerate with an acceleration $\vec{\mathbf{a}}$. What does observer B see as the acceleration of the object?

1. $\vec{\mathbf{a}}$
2. $-\vec{\mathbf{a}}$
3. Zero.
4. Depends on the direction of the relative velocity of B to A.

Problem 6 (2.5 points)

An object starts from rest and travels a distance d in time t when a constant force F acts on the object. What constant force must act on the object in order for it to start from rest and travel the same distance in a time $t/2$?

1. $4F$
2. $F/4$
3. $2F$
4. $F/2$

Problem 7 (2.5 points)

When a person with a mass of 98.4 kg stands on a spring scale in an elevator, the scale reads 0 N. Which statement about the elevator is true?

1. The elevator is stationary.
2. The elevator is moving downward with a velocity of 9.8 m/s.
3. The elevator is accelerating upward with an acceleration of 9.8 m/s^2.
4. The elevator is accelerating downward with an acceleration of 9.8 m/s^2.

Problem 8 (2.5 points)

A car travels around a curve of radius r at constant speed v. Its acceleration has a magnitude a. If the car rounds the same curve so that its acceleration is $2a$, what will its speed be?

1. $v/2$
2. $2v$
3. $4v$
4. $\sqrt{2}\,v$

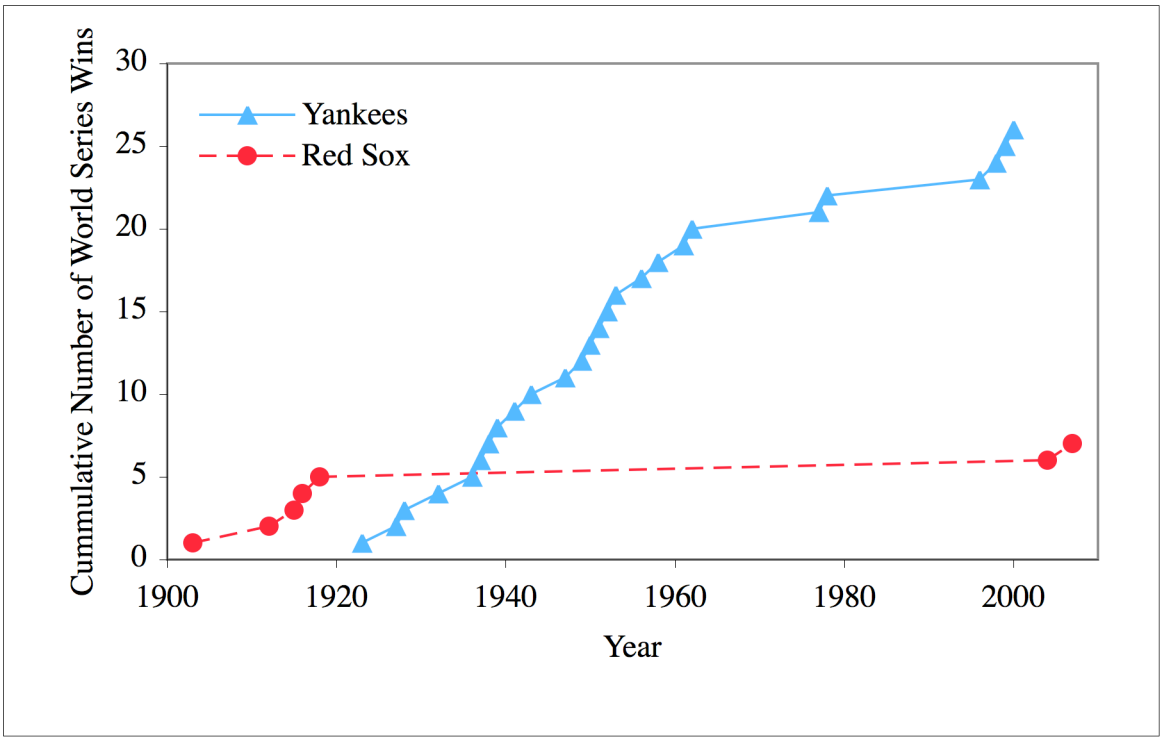
Problem 9 (2.5 points)

A car travels around a curve of radius r at constant speed v. Its acceleration has a magnitude a. If the car rounds a different curve at the same speed such that its acceleration is $2a$, what will the radius of the curve be?

1. $2r$
2. $r/2$
3. $4r$
4. $\sqrt{2}\,r$

Problem 10 (2.5 points)

The following graph shows the cumulative World Series wins of the Yankees and of the Red Sox, as function of Year. After careful examination of these scientific data, which is the better team?



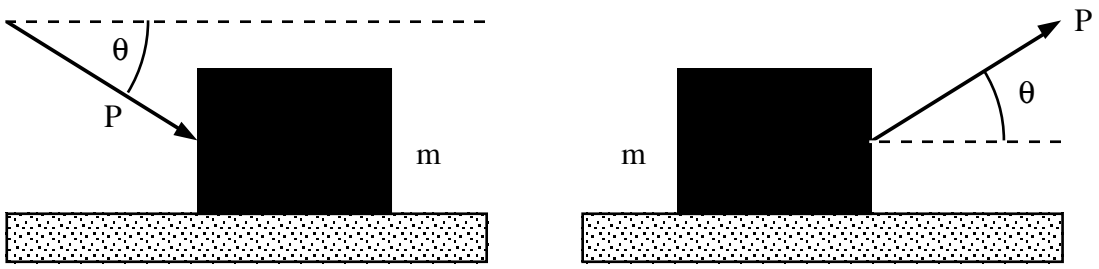
1. The Yankees.
2. The Yankees.
3. The Yankees.
4. I do not know.

Problem 11 (25 points) **Answer in Exam Booklet 1**

A block with mass m is pushed along a horizontal floor by a force P that makes an angle θ with the horizontal, as shown in Figure a. The coefficients of kinetic and static friction between the block and the floor are μ_k and μ_s, respectively.

a) Calculate the maximum force that can be applied without moving the block.

b) The applied force P is larger than the maximum force calculated in a). As a consequence, the block will start to move. Calculate the acceleration of the block.



(a) (b)

Instead of pushing the block with a force P, we can pull the block with the same force P (see Figure b).

c) Calculate the maximum force that can be applied without moving the block. Is this force larger or smaller than the maximum force calculated in a)?

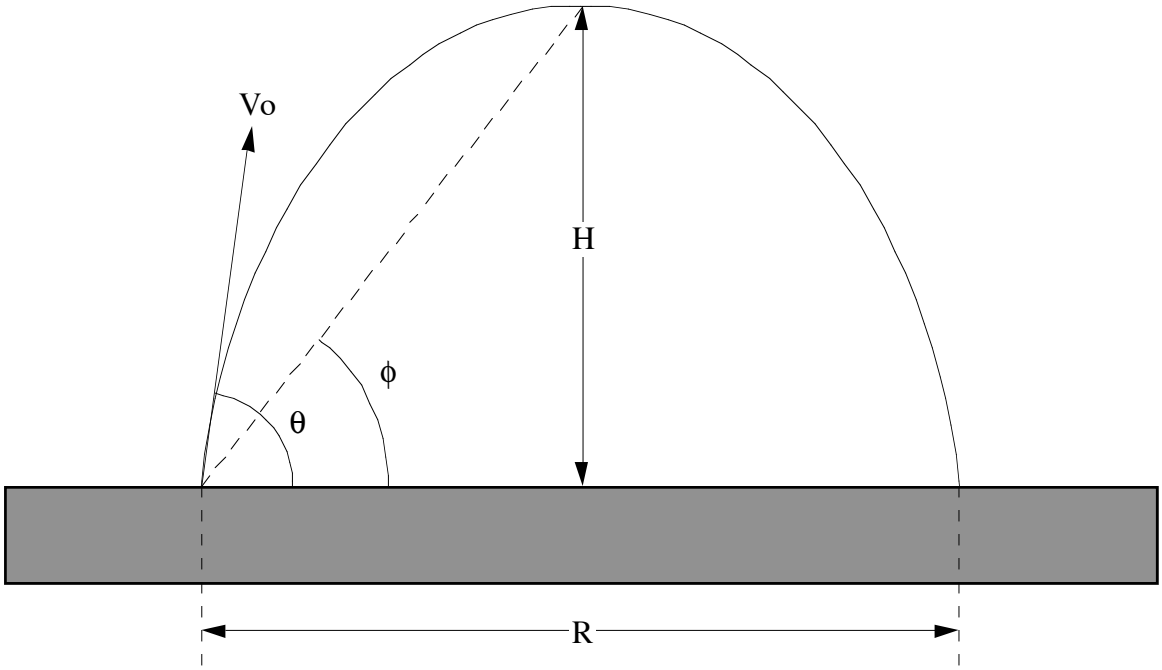
d) Calculate the acceleration of the block.

e) In which situation (block being pulled or pushed) will the block have the highest kinetic energy when it has been displaced over a distance d? Your answer needs to be well motivated.

Express all you answers in terms of g, m, P, d, μ_k, μ_s, and θ.

Problem 12 (25 points) **Answer in Exam Booklet 1**

A projectile of mass m is fired from ground level with an initial speed v_0 at an angle θ above the horizontal (see Figure).



a) Calculate the time at which the projectile hits the ground again.

b) Calculate the range R of the projectile (note: you will not receive any credit if you just write down the formula of the range presented in the text book).

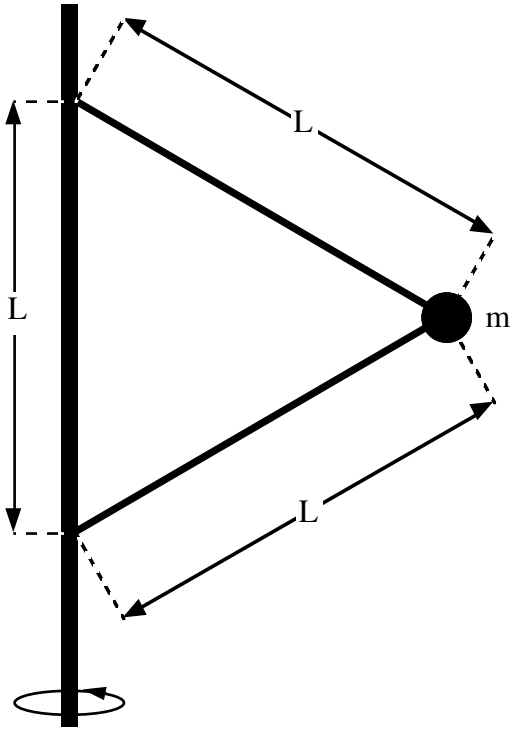
c) Find a relation between the maximum height H and the range R in terms of θ.

d) Find a relation between the elevation angle ϕ of the highest point, as seen from the launch point, and the firing angle θ (see Figure).

Express all your answers in terms of g, m, v_0, and θ.

Problem 13 (25 points) **Answer in Exam Booklet 2**

A ball of mass m is attached to a rigid vertical rod by means of two massless strings with length *L*. The strings are attached to the rod at points a distance *L* apart (see Figure). The system is rotating about the axis of the rod, both strings being taut and forming an equilateral triangle. The tension in the upper string is T_1.



a) Draw a free-body diagram, showing all forces acting on the ball.

b) What is the tension in the lower string?

c) What is the net force on the ball at the instant shown in the Figure? You need to specify both the magnitude and the direction of the force in terms of the variable provided.

d) What is the speed of the ball?

Express all your answers in terms of g, L, m, and T_1.

SCRATCH PAPER

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