Final Examination
Physics 109, Fall 2007

Name:_____

1. (4 Points) There are four basic quantities involved in the equations that describe motion under constant acceleration. What are they?
x = distance, v = velocity, a = acceleration and t = time

2. (4 Points) What four equations are used to relate these quantities to one another?
$v = v_0 + at$
$x = x_0 + ½ (v_0 + v)t$
$x = x_0 + v_0 t + ½ at^2$
$v2 = v_0^2 + 2a(x-x_0)$

3. (4 Points) Your friend reacts to something you tell her with the statement, "I feel about that as I would if someone had told me that F= 1.1 ma!" Does your friend agree or disagree with what you told her? Why?
Disagrees. F = 1.1 ma violates, or is an incorrect statement of Newton's Second Law

4. (6 Points) A rocket lifting off from Cape Canaveral is an example of what basic principle?
Newton's Third Law, for every action there is an equal and opposite reaction.

Why?

The expulsion of exhaust out the rear of the rocket nozzle causes a corresponding forward force to be exerted on the rocket.

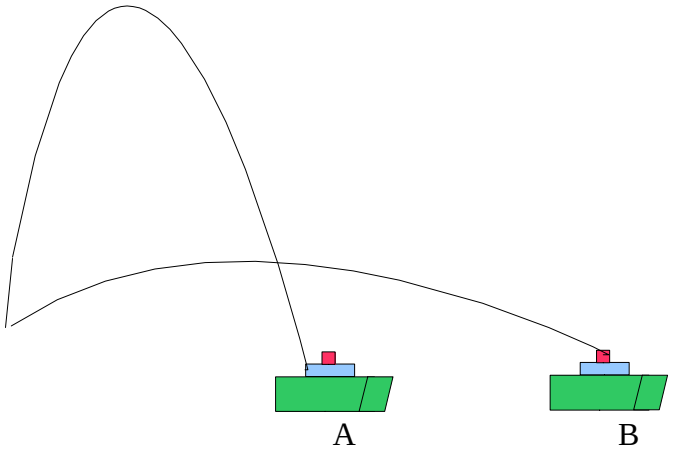
5. (6 Points) Given two vectors, $\mathbf{A} = (4\mathbf{i} + 1\mathbf{j})$ and $\mathbf{B} = (-1\mathbf{i} + 4\mathbf{j})$

What is the sum of these two vectors? $\mathbf{A} + \mathbf{B} = (3\mathbf{i} + 5\mathbf{j})$

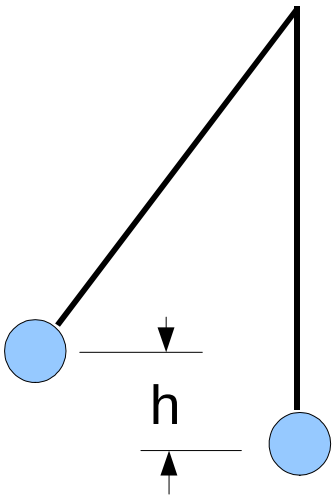
What is the dot product of these two vectors? $\mathbf{A} \cdot \mathbf{B} = -4 + 4 = 0$

What is the cross product of these two vectors? **A x B** = (16 -(-1)) **k** = 17 **k**

6. (6 Points) Two projectiles are fired at the same time, with the same muzzle velocity, at the two ships shown below. Neglecting air resistance, which ship is hit first? Ship B
Why?
Because the time of flight of a projectile is proportional to the height of its path, given the same initial velocity.



7. (6 Points) How did the Binary Star experiment that we performed differ from the real case of a binary star?
The spring between the pucks gave a force that is the opposite to the force of gravity in that it leads to a force that is larger if the pucks are further apart. If gravity were acting, the force would be lower if the stars were farther apart.



8. (10 Points) Given two pendulums, the first (on the left) of mass m and the stationary one of mass 2m. The first is released at height h, and the two pendulums stick together upon impact. How high do they rise after impact?

KE(1) = ½ $mv_1^2 = mgh_1$ KE(2) = ½ $(3m)v_2^2 = 3mgh_2$

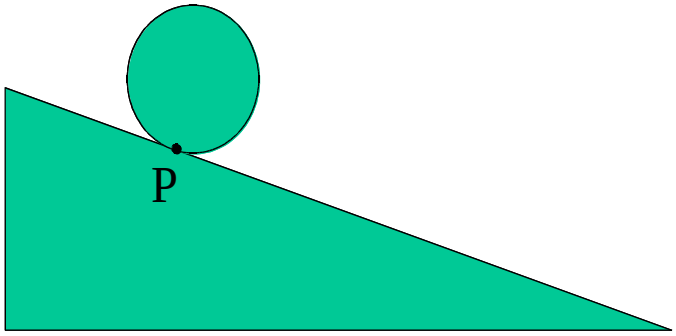
Using conservation of momentum, $mv_1 = 3mv_2$ so, $v_2 = v_1/3$ and $v_2^2 = v_1/9$

then, $v_1^2 = 2gh_1$ and ½ $(3m)\ 2gh_1/9 = 3mgh_2$ and **$h_2 = h_1/9$**

9. (4 Points) Why can we use conservation of momentum in dealing with collision problems?

Because there are no external forces acting, and thus the total momentum cannot change.

10. (8 Points) Why does the cylinder roll down the inclined plane? I am looking for two reasons.



1. Gravity leads to a torque on the cylinder
2. There is friction at point P.

11. (6 Points) Which would reach the bottom of an inclined plane first, assuming they started rolling from the same place at the same time—a Solid Cylinder or a Hollow Cylinder?

The **solid** cylinder.

Why? The hollow cylinder has a higher rotational moment of inertia and thus accelerates more slowly.

Do the diameters or the masses of the cylinders make any difference?

No. mass and diameter do not appear in the equation for the velocity at the bottom of the ramp:

$$v = (2gh/(1+c))^{1/2}$$

12. (8 Points) You are standing on a rotatable platform, holding a rotating bicycle wheel with its axis horizontal, and the top of the wheel going away from you.

a. What is the direction of the Angular Momentum vector?

It points horizontally to the left.

b. What happens when you tilt the left end of the axis of the wheel down 45 degrees?

You rotate to the left

c. Why did the tilt cause this result?

You need to counteract the vertical (downward) component of angular momentum caused by the tilt by rotating to the left, which gives an upward angular momentum vector.

13. (8 Points) Why does a tilted gyroscope, with its rotor spinning, not fall?

The requirement to conserve angular momentum generates a torque that counteracts the force of gravity.

What does it do instead?

The gyroscope precesses.

14. (12 Points) We did not go out to test the pendulum behavior using a swing in the playground. However, assuming that we did do this experiment, what do you think would happen in the following three different trials? What do you think is the reason we make each of these observations?

a. Two people of different masses sit separately on the swing, and after starting it with a push, allow the swing to go back and forth at its natural frequency for each person.

We would measure the same frequency because mass is not included in the frequency equation

$\omega = \text{sqrt}(g/l)$

b. One person sits on the swing and its frequency is observed, then the same person stands on the swing and its frequency is observed again.

We would measure a higher frequency with the person standing because l is smaller.

c. A brave person sits on the swing and drives it to very large amplitude, after first measuring its natural frequency at small amplitude.

The large amplitude frequency would be different because the approximation that $\text{Sin } \theta = \theta$ does not hold at large angles.

15. (8 Points) If you only had a spring and a strap, how would you determine the mass of another astronaut if you both were in an orbiting satellite? (You know the spring constant, k.)

Strap the astronaut to the spring, set him into harmonic motion, and measure the period, T or the frequency, f. $\omega = \text{Sqrt}(k/m)$ so, $m = k/\omega^2$