University of California at Berkeley
Department of Physics
Physics 7A, Fall 2000

Final examination, Prof. Jacobsen
December 14, 8AM to 11AM

You will be given three hours to work this exam. No books are permitted, but you may use a handwritten sheet of notes no larger than one standard sheet of paper.

Your description of the physics involved in a problem is worth significantly more than any numerical answer. Show all work, and take particular care to explain what you are doing.

Write your answers directly on the exam, and if you have to use the back of a sheet, make sure to put a note on the front. Do not use a blue book or scratch paper.

The multiple choice questions are worth one point each for a total of 28 points. The multipart problems are labeled with their point values, which total 72 points. To ensure appropriate partial credit we grade each problem as a whole. The exam total is one hundred points.

Please use $g = 10\ m/sec^2$

$\sin 45° = 0.707$, $\cos 45° = 0.707$, $\sin 30° = 0.500$, $\cos 30° = 0.866$

$$\frac{1}{2}\rho v^2 + yg\rho + P = \text{constant} \qquad F = \frac{GM_1M_2}{r^2} \qquad \omega = \sqrt{\frac{k}{m}} \qquad \omega = \sqrt{\frac{g}{l}} \qquad \sum \vec{F} = m\vec{a}$$

Rotational Inertias for radius R or length L:

sphere about axis: $(2/5)MR^2$	spherical shell about axis: $(2/3)MR^2$
disk about axis: $(1/2)MR^2$	hoop about axis: MR^2
rod about perpendicular at midpoint: $ML^2/12$	rod about perpendicular at end: $ML^2/3$

NAME:_____

SID NUMBER: _____

DISCUSSION SECTION NUMBER: _____

DISCUSSION SECTION DAY/TIME:_____

MC	
II	
III	
IV	
V	
VI	
total	

Read the problems carefully.

Try to do all the problems.

If you get stuck, go on the the next problem.

DON'T GIVE UP! Try to remain relaxed and work steadily.

1) A hydraulic press has one piston of diameter 2 cm and the other piston of diameter 8 cm. If a 100 N. force is applied to the smaller piston, the force exerted on the larger piston will be

a) 6.25 N
b) 25 N
c) 100 N
d) 400 N
e) 1600 N

2) Water waves in the sea are observed to have a wavelength of 1000 m and a frequency of 0.07 Hz. The velocity of these waves is:

a) 0.0007 m/s
b) 7 m/s
c) 70 m/s
d) 700 m/s
e) none of these

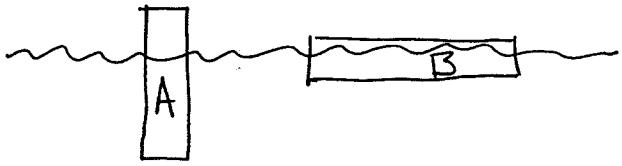
3) Constructive interference between two sinusoidal waves of the same frequency occurs if they

a) travel in opposite directions and are 180° out of phase
b) travel in the same direction and are 180° out of phase
c) travel in opposite directions and are in phase
d) travel in the same direction and are in phase
e) travel in the same direction and are 90° out of phase

4) A fluid is undergoing steady flow. Therefore:

a) the flow is not uphill or downhill
b) the velocity of any given molecule does not change
c) the pressure does not vary from point to point
d) the velocity at any given point does not vary with time
e) the density does not vary from point to point

5) Two identical blocks of ice float in water as shown. Then:



a) block A displaces a greater volume of water since the pressure acts on a small bottom area
b) block B displaces a greater volume of water since the pressure is less on the bottom
c) the two blocks displace equal volumes of water since they have the same weight
d) the density of block A is less than that of block B
e) the density of block A is more than that of block B

6) Several cans of different sizes and shapes are all filled with the same liquid to the same depth. Then:

a) the weight of the liquid is the same for all cans
b) the force of the liquid on the bottom of each can is the same
c) the least pressure is at the bottom of the can with the largest bottom area
d) the greatest pressure is at the bottom of the can with the largest bottom area
e) the pressure on the bottom of each can is the same

7) A constriction in a pipe reduces its diameter from 4.0 cm to 2.0 cm. Where the pipe is wide the fluid velocity is 8.0 m/s. Where it is narrow the fluid velocity is:

a) 2.0 m/s
b) 4.0 m/s
c) 8.0 m/s
d) 16 m/s
e) 32 m/s

8) A body is in equilibrium under the combined action of several forces. Then:

a) all the forces must be applied at the same point
b) the lines of action of all the forces must pass through center of gravity of the body
c) all of the forces are composed of pairs of equal and opposite forces
d) the sum of the components of all the forces in any direction must equal zero
e) any two of the forces must be balanced by a third force

9) A string of length 50 cm is held fixed at both ends. This string CANNOT be made to vibrate with a wavelength of

a) 200 cm
b) 100 cm
c) 50 cm
d) 33.3 cm
e) 25 cm

10) The amplitude and phase constant of the motion of an oscillator are determined by:

a) the frequency
b) the angular frequency
c) the initial displacement alone
d) the initial velocity alone
e) both the initial displacement and velocity

11) In simple harmonic motion, the restoring force must be proportional to the

a) amplitude
b) displacement
c) frequency
d) displacement squared
e) velocity

12) Let F_1 be the magnitude of the gravitational force exerted on the sun by the earth and F_2 be the magnitude of the force exerted on the earth by the sun. Then

a) F_1 is much greater than F_2

b) F_1 is slightly greater than F_2

c) F_1 is equal to F_2

d) F_1 is slightly less than F_2

e) F_1 is much less than F_2

13) The principle of fluid pressure which is used in hydraulic brakes or lifts is that:

a) pressure is the same at all levels in a liquid

b) increases of pressure are transmitted equally to all parts of a fluid

c) the pressure at a point in a fluid is due to the weight of the fluid above it

d) increases of pressure can only be transmitted through fluids

e) the pressure at a given depth is proportional to the depth in the fluid

14) A sinusoidal force with a given amplitude is applied to an oscillator. At resonance the amplitude of the oscillation is limited by

a) the damping force

b) the initial velocity

c) the initial amplitude

d) the force of gravity

e) none of the above

15) In the formula $F = Gm_1m_2/r^2$, the quantity G

a) depends on the local value of g

b) is a universal constant of Nature

c) is greatest at the surface of the Earth

d) is used only when the Earth is one of the two masses

e) is releated to the sun in the same way that g is related to the Earth

16) In simple harmonic motion, the magnitude of the acceleration is greatest when the

a) velocity is maximum

b) displacement is zero

c) force is zero

d) displacement is maximum

e) none of these

17) A uniform U-tube is partially filled with water. Oil, of density 0.75 g/cm^3, is poured into the right arm until the water level in the left arm rises 3cm. The length of the oil column is then:

a) 2.25 cm

b) 8 cm

c) 6 cm

d) 4 cm

e) need to know the cross sectional area of the U-tube

18) A force acting on a particle is conservative if

a) its work equals the change in kinetic energy of the particle

b) it obeys Newton's second law

c) it obeys Newton's third law

d) its work depends on the end points of the motion, not on the path between them

e) it is not a frictional force

19) An object is held in place by friction on an inclined surface. The angle of inclination is increased until the object starts moving. If the surface is kept at this angle, the object

a) slows down.

b) moves at uniform speed.

c) speeds up.

d) none of the above

20) A rock, initially at rest with respect to Earth and located an infinite distance away is released and accelerates toward Earth. An observation tower is built 8 Earth-radii high to observe the rock as it plummets to Earth. Neglecting friction, the rock's speed when it hits the ground is

a) twice
b) three times
c) four times
d) six times
e) eight times
f) nine times
g) sixteen times

its speed at the top of the tower.

21) A compact car and a large truck collide head on and stick together. Which vehicle undergoes the larger acceleration during the collision?

a) car
b) truck
c) Both experience the same acceleration.
d) Can't tell without knowing the final velocity of combined mass.

22) A figure skater stands on one spot on the ice (assumed frictionless) and spins around with her arms extended. When she pulls in her arms, she reduces her rotational inertia and her angular speed increases so that her angular momentum is conserved. Compared to her initial rotational kinetic energy, her rotational kinetic energy after she has pulled in her arms must be

a) the same.
b) larger because she's rotating faster.
c) smaller because her rotational inertia is smaller.

23) An object moves in a circle at constant speed. The work done by the centripetal force is zero because:

a) there is no friction

b) the displacement for each revolution is zero

c) the average force for each revolution is zero

d) the magnitude of the acceleration is zero

e) the centripetal force is perpendicular to the velocity

24) Suppose a golf ball is hurled at a heavy bowling ball initially at rest and bounces elastically from the bowling ball. After the collision, which ball has the greater momentum?

a) the golf ball

b) the bowling ball

c) both must be the same

d) depends on something we haven't been told

25) Suppose a golf ball is hurled at a heavy bowling ball initially at rest and bounces elastically from the bowling ball. After the collision, which ball has the greater kinetic energy?

a) the golf ball

b) the bowling ball

c) both must be the same

d) depends on something we haven't been told

26) A massless rope passes over a massless pulley attached to the ceiling. A large mass is tied to one end, and a smaller mass is tied to the other. Starting from rest the large mass moves downward and the smaller mass moves upward with the same acceleration. Which of the following is true for the system consisting of the two masses?

a) the center of mass remains fixed

b) the net external force is zero

c) the velocity of the center of mass is constant

d) the acceleration of the center of mass is g, downward

e) none of the above

27) A large wedge rests on a horizontal frictionless surface. A block starts from rest and slides down the including surface of the wedge, which is not frictionless. During the motion of the block, the center of mass of the block and wedge

a) does not move

b) moves horizontally with constant speed

c) moves horizontally with increasing speed

d) moves vertically with increasing speed

e) moves horizontally and vertically

28) We may apply conservation of energy to a cylinder rolling down an incline without slipping, thus saying no work is done by friction, because

a) there is no friction present

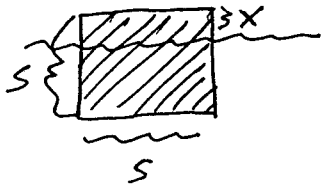
b) the angular velocity of the center of mass about the point of contact is zero

c) the coefficient of kinetic friction is zero

d) the linear velocity of the point of contact (relative to the surface) is zero
the coefficients of static and kinetic friction are equal in this case

II) (20 points) The floating block

A cubical block of density ρ_b is floating in water of density $\rho_w = 1$. The block has sides of length S. Assume that the densities are similar, i.e. only a small part of the block is above the surface of the water, so you don't have to worry about the block flipping over. (This situation is stable)



a) In terms of the given quantities, how much of the block is exposed? (x in the figure)

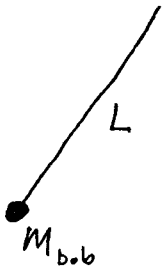
b) If I now want to push the block down by Δx, how much force do I need to exert? In which direction? If I want to raise the block by Δx, how much force do I need to exert? In which direction? Put your answer in the form of $F = k\,\Delta x$, giving an explicit expression for k including sign.

c) Does the floating block form a simple harmonic oscillator? If not, give a really convincing explanation of why not. If so, find the period of the oscillation.

d) Assume the velocity of surface waves in fresh water is 60 meters/second. What is the wavelength of the disturbance I get in the surface of the water if I push the block down and release it?

III) (20 points) Two oscillations of a pendulum

In all parts, answers should be in terms of only g, numerical constants like 2 and π, and quantities given in the problem.



a) We have a pendulum of length L and mass M_{bob}. What is its period of oscillation?

In this part, ignore the effect of air (if any) and the mass of the string and consider only small oscillations.

b) What is the tension in the string when it is hanging straight down and stationary (e.g. the pendulum bob is not moving)?

c) If the string has mass m_{string}, what is the velocity of waves on the string? You can assume that m_{string} is very, very much less than M_{bob}.

d) If you pluck the string to start the lowest order standing wave, what is its period of oscillation?

e) There are two kinds of vibrations that can be present here (pendulum or standing wave). Which has the shorter period? What is the ratio of their periods?

IV) (10 points) Geo-synchronous orbit

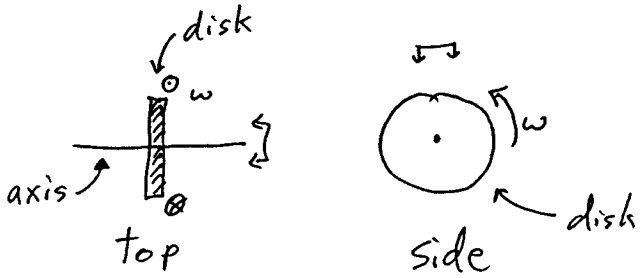
In this problem, we consider a satellite in a circular orbit at a certain distance $\mathbf{r_0}$ from the surface of the Earth. The earth has radius $\mathbf{R_e}$ and mass $\mathbf{M_e}$. Please make sure the grader can understand both your answer to each question, and how you're justifying it.

a) The time it takes the satellite to orbit the earth is related to the orbit radius $\mathbf{r_0}$. Find the value of $\mathbf{r_0}$ that results in a 24 hour period for the satellite, the so-called geosynchronous orbit.

b) Find the total energy (kinetic plus potential) for the satellite in this orbit, and compare it to the total energy for the satellite while sitting in a hanger on the Earth's surface. What is their ratio?

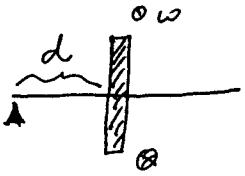
V (12 points) The gyroscope

A gyroscope is made from a thin disk of mass M and radius r. It is rotating about its axis with an angular velocity ω. (You can consider this to be a very large angular velocity). The picture to the left shows a top and side view of the gyroscope at some particular moment. The axis is horizontal.



a) What is the gyroscope's angular momentum? (Specify direction by putting an arrow on the drawing above)What is its rotational kinetic energy?

b) The axis of the gyroscope is supported at a distance d from the center (see drawing). The gyroscope then precesses in a horizontal plane. What is the period of this precession?



2nd side view

VI) (10 points) Bicycle wheels and merry-go-rounds

Suppose you are standing on the center of a merry-go-round that is at rest. You are holding a rotating bicycle wheel over your head so that its rotation axis is pointing upward. The wheel is rotating counterclockwise when observed from above along your axis of rotation.

a) Suppose you now move the wheel so that its axis is horizontal. What happens to you? Specifically, are you and the merry-go-round turning? Which way?

b) What happens if you then point the axis of the wheel downward so that the wheel rotates clockwise as viewed from above? Specifically, are you and the merry-go-round turning? Which way? If you are turning in both parts (a) and (b), are you now turning faster/slower/same angular speed than you were in part (a)?