SAMPLE FINAL EXAM - PHYSICS 1301.1

This is a closed book, closed notes quiz. Calculators are permitted. The **ONLY** formulas that may be used are those given below. Define all symbols and justify all mathematical expressions used. Make sure to state all of the assumptions used to solve a problem. Credit is given only for a logical and complete solution that is clearly communicated. Partial credit will be given for a well communicated problem solving strategy based on correct physics. MAKE SURE YOUR NAME, ID #, TAs NAME, AND SECTION # IS ON EACH PAGE!! Each problem is worth 25 points: In the context of a unified solution, a useful picture, defining the question, and giving your approach is worth 6 points; a complete physics diagram defining the relevant quantities, identifying the target quantity, and specifying the relevant equations is worth 7 points; planning the solution by constructing the mathematics leading to an algebraic answer and checking the units of that answer is worth 7 points; calculating a numerical value with correct units is worth 3 points; and evaluating the validity of the answer is worth 2 points. The 30 multiple choice questions are worth 1point each.

Useful Mathematical Relationships:

If $Ax^2 + Bx + C = 0$, then $x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$

$$\frac{d(z^n)}{dz} = nz^{n-1}\ ,\ \frac{d(\cos z)}{dz} = -\sin z\ ,\ \frac{d(\sin z)}{dz} = \cos z\ ,\ \frac{df(z)}{dt} = \frac{df(z)}{dz}\frac{dz}{dt}\ ,\ \int\left(\frac{dw}{dz}\right)dz = w,$$

$$\frac{d}{dz}\int w dz = w\ ,\ \int z^n dz = \frac{z^{n+1}}{n+1}(n \neq -1)$$

Fundamental Concepts and Principles:

$\bar{v}_x = \frac{\Delta x}{\Delta t}$	$\bar{s} = \frac{dist}{\Delta t}$	$\bar{a}_x = \frac{\Delta v_x}{\Delta t}$	$\theta = \frac{\Delta C}{r}$	$\bar{\omega} = \frac{\Delta\theta}{\Delta t}$	$\bar{\alpha} = \frac{\Delta\varpi}{\Delta t}$
$v_x = \frac{dx}{dt}$	$s = \frac{dr}{dt}$	$a_x = \frac{dv_x}{dt}$	$\omega = \frac{d\theta}{dt} = \frac{v_t}{r}$	$\alpha = \frac{d\omega}{dt} = \frac{a_t}{r}$	$\sum \vec{F} = m\vec{a}$
$\tau = rF_t$	$\sum \vec{\tau} = I\vec{\alpha}$	$W = \int_{path} \vec{F}\bullet d\vec{\ell}$	$KE = \frac{1}{2}mv^2$	$E_f - E_i = \Delta E_{transfer}$	$\vec{p} = m\vec{v}$
$\vec{p}_f - \vec{p}_i = \Delta\vec{p}_{transfer}$	$\vec{p}_{transfer} = \int \vec{F}dt$	$\vec{r}_{com} = \frac{\sum m_i \vec{r}_i}{\sum m_i} = \frac{\int \vec{r}dm}{\int dm}$		$I = \sum m_i r_i^2 = \int r^2 dm$	$\vec{L} = I\vec{\omega}$
$\vec{L}_f - \vec{L}_i = \Delta\vec{L}_{transfer}$	$\vec{L} = \vec{r}\times\vec{p}$	$\vec{L}_{transfer} = \int \vec{\tau}dt$		$f = \frac{1}{T}$	

Under Certain Conditions:

$x_f = \frac{1}{2}a_x(\Delta t)^2 + v_{ox}\Delta t + x_o$	$F = \mu_k F_N$	$F \leq \mu_s F_N$	$F = k\Delta x$	$KE = \frac{1}{2}I\omega^2$	$PE = mgy$	$PE = \frac{1}{2}kx^2$
$\theta_f = \frac{1}{2}\alpha(\Delta t)^2 + \omega_o\Delta t + \theta_o$	$a = \frac{v^2}{r}$	$I = I_{cm} + Md^2$	$v_{cm} = r\omega$	$x = A\cos(2\pi ft + \Phi)$		

Useful constants: 1 mile = 5280 ft, g = 9.8 m/s^2 = 32 ft/s^2

Problems

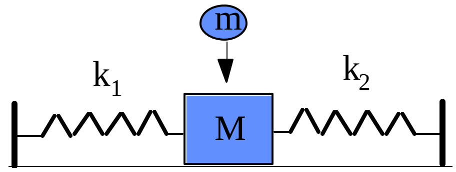
1. While working in a mechanical structures laboratory, your boss assigns you to test the strength of ropes under different conditions. Your test set-up consists of two ropes attached to a 30 kg block which slides on a 5.0 m long horizontal table top. Two low friction, light weight pulleys are mounted at opposite ends of the table. One rope is attached to each end of the 30 kg block. Each of these ropes runs horizontally over a different pulley. The other end of one of the ropes is attached to a 12 kg block which hangs straight down. The other end of the second rope is attached to a 20 kg block also hanging straight down. The coefficient of kinetic friction between the block on the table and the table's surface is 0.08. The 30 kg block is initially held in place by a mechanism that is release when the test begins so that the block is accelerating during the test. During this test, what is the force exerted on the rope supporting the 12 kg block?

2. You have been asked to review the safety of workers washing windows on skyscrapers. The platform they stand on to get to the windows is 2.0 feet wide and 12 feet long. It weighs 130 lbs. It is supported by two cables, one at each end, mounted on-center to prevent the platform from tipping over as it is pulled up the side of the building. You worry whether the cables are strong enough, so you observe how the window washers work. There are two workers on the platform as it goes up a 200-ft high building at a constant speed of 3.0 ft/s. You notice that one worker, who weighs 115 lbs, stands 2.5 ft from one cable while the other, who weighs 160 lbs, stands 4.0 ft from the other cable. Both stand 1.0 ft from the sides. The platform has a uniform mass distribution and is of negligible thickness. As an example, you decide to calculate the tension in each rope for this situation.

3. You have been hired as part of a team to determine procedures for assembling a space station. In the construction, two sections of the station are coupled together using a very large diameter ring. Your task is to determine how to maneuver the ring into position. One suggestion is to have a worker approach the motionless ring at a constant velocity tangent to the ring. Upon reaching the ring, the worker grabs it and holds on. Your assignment is to calculate the ring's subsequent motion as a function of the worker's initial velocity. The project's specifications will give the mass of the ring and the worker (including space suit) as well as the radius of the coupling ring. For simplicity, you assume that the trajectory of the worker is in the plane of the ring. Your boss has suggested that you characterize the motion in terms of the final translational velocity of the center of mass of the ring and worker and their final rotational velocity about that center of mass.

4. An unfortunate cat is perched at the top of a straight ladder that is just starting to fall from a freestanding vertical position. Is it better for the cat to let go and simply drop vertically to the ground or for the cat to ride down to the ground on the end of the ladder? To answer this question, compare the speeds with which the cat arrives at the ground in the two cases. Assume that the mass of the cat is 5.0 kg, the mass of the ladder is 15.0 kg, the length of the ladder is 4.0 m, and that the ladder falls without slipping along the ground. The moment of inertia of the ladder about an axis through its end is $ML^2/3$, where M is the mass of the ladder and L is its length.

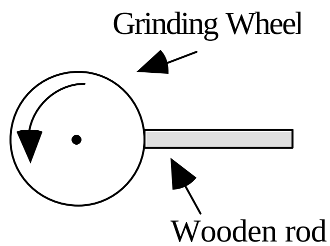
5. A block of mass M rests on a frictionless surface and is connected to two springs as shown in the figure. The two springs are of the same length but have different spring constants k_1 and k_2. The mass is initially oscillating horizontally about its equilibrium position with an amplitude A. At the instant the block is passing through its equilibrium position, a ball of putty of mass m falls gently onto it and sticks. What are the frequency and maximum velocity of the motion after the collision?



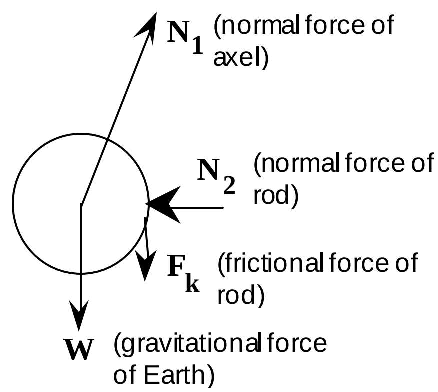
6. You are on a team devising new computer games that simulate reality. In this game you decide to roll a boulder off a cliff to land on the enemy below. To test your ideas in the lab, you release a ball so that it rolls without slipping down a ramp and then continues rolling on to a horizontal table. The ball then goes off the table and lands on the floor. You need to predict the distance from the table legs that the ball lands on the floor? You know the height of the center of the ball above the floor when it is released, the mass of the ball, the radius of the ball, and the height of the table above the floor. The moment of inertial of the ball rotating about its center is 2/5 that of a ring of the same mass and radius.

Conceptual Questions

1. A grinding wheel, just after the motor is turned off, rotates with a high angular velocity, as shown in the diagram at right. A wooden rod is pushed toward the center on the outside edge of the grinder.



A free body diagram of the grinder wheel is shown at right. Which force(s) exert a torque on the grinding wheel about its center?



(a) **W** and $\mathbf{F_k}$

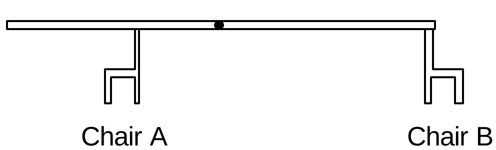
(b) $\mathbf{N_2}$ and $\mathbf{F_k}$

(c) $\mathbf{N_2}$ and **W**

(d) $\mathbf{N_2}$

(e) $\mathbf{F_k}$

2. A uniform plank is supported by the backs of two chairs, as shown in the diagram at right. How do the magnitudes of the **forces** exerted by the two chairs compare?

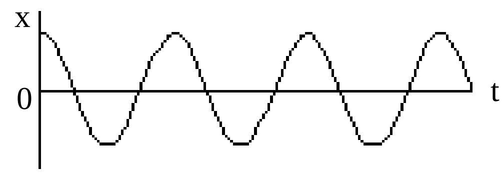


(a) Chair A exerts a greater force on the plank than Chair B.
(b) Both chairs exert equal forces on the plank.
(c) Chair B exerts a greater force on the plank than Chair A
(d) It is impossible to tell which force is larger without knowing the weight of the plank.
(e) It is impossible to tell which force is larger without knowing more about the chairs.

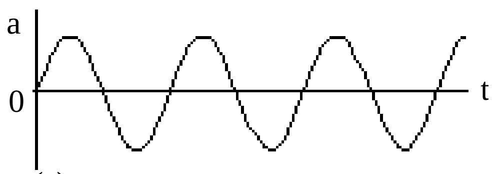
3. If an object is in simple harmonic motion, its

(a) velocity is proportional to its displacement.
(b) acceleration is proportional to its displacement.
(c) kinetic energy is proportional to its displacement.
(d) period is proportional to its displacement.
(e) frequency is proportional to its displacement.

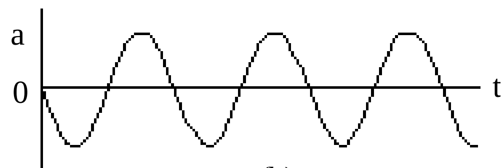
4. The graph represents the motion of a mass attached to a horizontal spring undergoing simple harmonic motion.



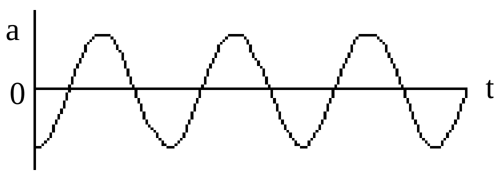
Which graph below is the *acceleration* versus time graph for the mass?



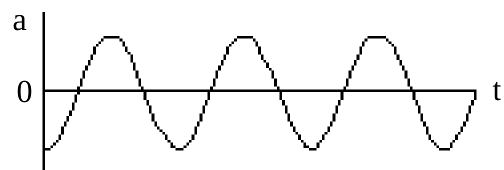
(a)



(b)



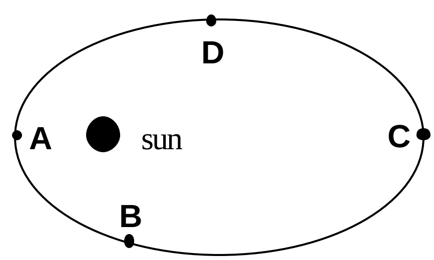
(c)



(d)

(e) None of the above.

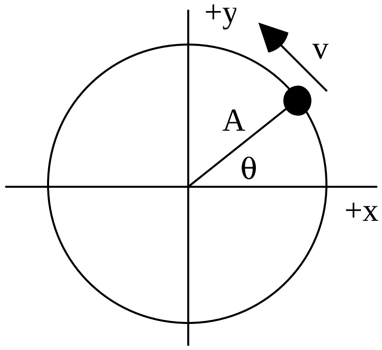
5. Haley's comet has an elliptical orbit around the sun, as shown in the figure at right. At which point in its orbit does it have its greatest angular momentum?



(a) Point A
(b) Point B
(c) Point C
(d) Point D
(e) Its angular momentum is the same everywhere.

6. A bucket is being lowered on a rope at **a constant speed**. Ignoring any effects due to the air:

a) the tension of the rope is greater than the weight of the bucket.
b) the tension of the rope is less than the weight of the bucket.
c) the tension of the rope is equal to the weight of the bucket.
d) which is greater depends on how fast the bucket is going.
e) there is no connection between the tension of the rope and the weight of the bucket.



7. In the diagram on the right of an object is in circular motion with an constant angular velocity ω. The object is at position x=+A, y=0 at time t=0. The y component of the object's **velocity** is given by

(a) A ω cos(ωt).
(b) -A ω sin(ωt).
(c) A ω.
(d) A ω tan(ωt).
(e) -A 2πf sin(2πft).

8. Which of the following is **true** for a simple harmonic oscillator?

(a) The velocity and acceleration are 180^{o} out of phase.
(b) The velocity is proportional to the displacement.
(c) The maximum values of the acceleration and displacement occur at the same places.
(d) The maximum values of the acceleration and velocity occur at the same places.
(e) None of the above.

9. A cockroach walks directly towards the center of a disk which is rotating freely with no external torques.

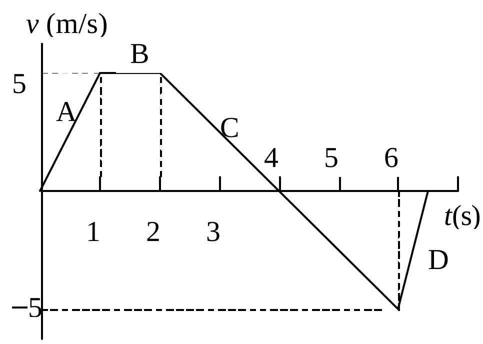
a) The angular speed of the disk will increase.
b) The angular speed of the disk will decrease.
c) The angular speed of the disk will stay constant.
d) The angular speed of the disk will increase or decrease depending on the speed of the cockroach.
e) We need more information to predict how the angular speed of the disk changes.

10. A 20 kg wooden block, initially at rest on a horizontal surface has a horizontal force of 80 N applied to it. The block moves 15 m in the direction of the applied force. The frictional force is 20 N. The block acquires a speed of approximately

a) 9.5 m/s
b) 90 m/s
c) 4.8 m/s
d) 11 m/s
e) 45 m/s

11. The velocity of an object, starting from rest at position $x = 0$ at time $t = 0$, is shown in the graph to the right below. Other than at $t = 0$, when is the position of the object equal to zero?

a) A, between 0 s to 1 s
b) B, between 1 s to 2 s
c) C, between 2 s to 6 s
d) D, between 6 s to 6.5 s
e) At no other time on this graph

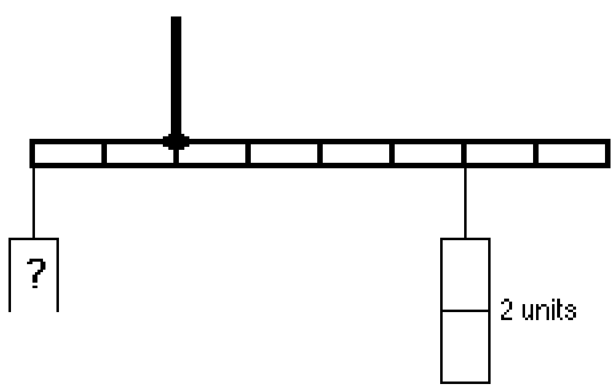


12. In the question above, when is the magnitude of the acceleration largest?

a) A, between 0 s to 1 s
b) B, between 1 s to 2 s
c) C, between 2 s to 6 s
d) D, between 6 s to 6.5 s

13. The mobile at the right hangs from a vertical string. The uniform **beam has a weight of one unit**. The lines on the beam are equally spaced. Determine the number of weight units that must be hung from the left side in order to balance the beam. **Do not** ignore the weight of the beam.

a) 2
b) 3
c) 4
d) 5
e) none of these.



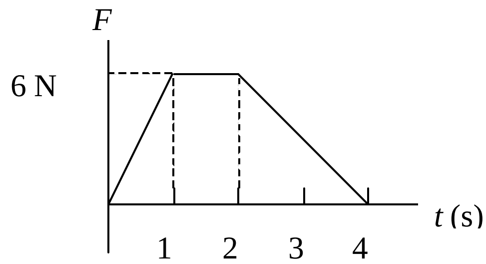
14. A ball rolls up a ramp. At the highest point the ball reaches,

a) its acceleration is zero
b) its acceleration is down the ramp
c) its acceleration is up the ramp
d) its acceleration is vertically down
e) its acceleration is vertically up

15. When a car moves in a circle with constant speed, its acceleration is

a) constantly increasing
b) constant in magnitude but not in direction
c) zero
d) constant in magnitude and direction
e) none of these

16. An 3-kg object moves along the *x* axis. It is subjected to a force *F* in the positive *x* direction; a graph of *F* as a function of time is shown below. Over the 4 seconds that the force is applied, the change in the momentum of the object is

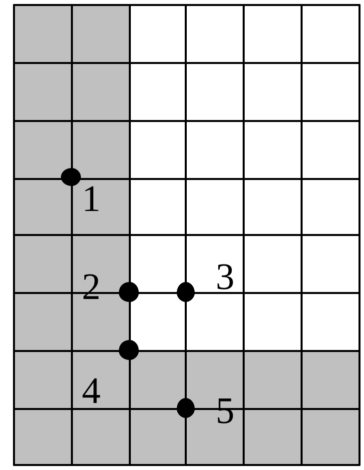


a) 1 kg·m/s
b) 2 kg·m/s
c) 5 kg·m/s
d) 15 kg·m/s
e) 45 kg·m/s

17. While ice skating, an 80-kg man runs into a 40-kg boy who is standing still on his skates. Which of the following statement is true?

(a) The man and boy exert equal magnitude forces on each other.
(b) The man exerts a greater force on the boy.
(c) The boy exerts a greater force on the man.
(d) Only the man exerts a force on the boy.
(e) Only the boy exerts a force on the man.

18. In the figure on the right, the L-shaped shaded piece is cut from a metal plate of uniform thickness. The point that corresponds to the center of mass of the L-shaped piece is



a) 1
b) 2
c) 3
d) 4
e) 5

19. A particle is acted on by a single constant force F and moves in a circle of radius R at a constant speed. The work done by F when the particle has made one revolution is

a) $F(2\pi R)$
b) $F(R)$
c) $F(\pi R)$
d) $F(2R)$
e) none of these

20. If a body moves in such a way that its linear momentum is constant, then

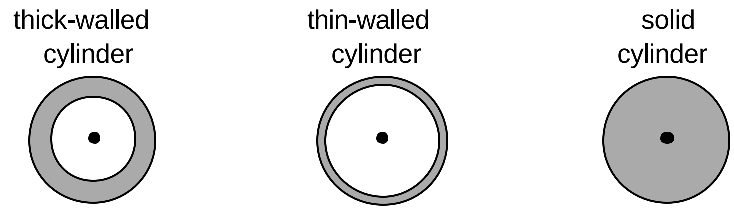
a) its kinetic energy is zero.
b) the net force acting on it must be zero.
c) its acceleration must be nonzero and constant.
d) its center of mass must remain at rest.
e) frictional forces must be negligible.

21. A 1-kg object has a head-on elastic collision with a 100-kg object, which is at rest, on a frictionless surface. After the collision,

a) the 1-kg object has the larger momentum (in magnitude)
b) the 100-kg object has the larger momentum (in magnitude)
c) they both have the same momentum (both in magnitude and in direction)
d) they both have equal momentum (in magnitude) but opposite in direction
e) the momentum is zero.

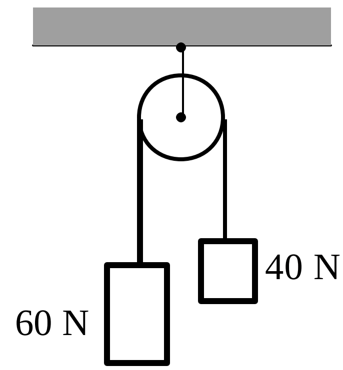
22. A uniform thick walled cylinder, a uniform thin walled cylinder, and a uniform solid cylinder all have the same mass and outer radius. Each cylinder is free to rotate about its central axis. Rank them according to their rotational inertia (moment of inertia) about that axis; greatest to least.

a) thick, thin, solid.
b) thick, solid, thin.
c) thin, thick, solid.
d) thin, solid, thick.
e) solid, thick, thin.

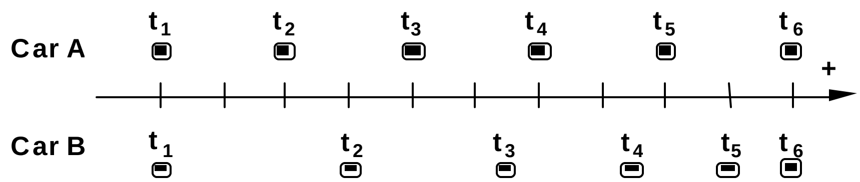


23. Two blocks (weights 40 N and 60 N) are connected by a light string that passes over a massless pulley as shown. The tension in the string is

a) 20 N
b) 40 N
c) 60 N
d) 100 N
e) none of these



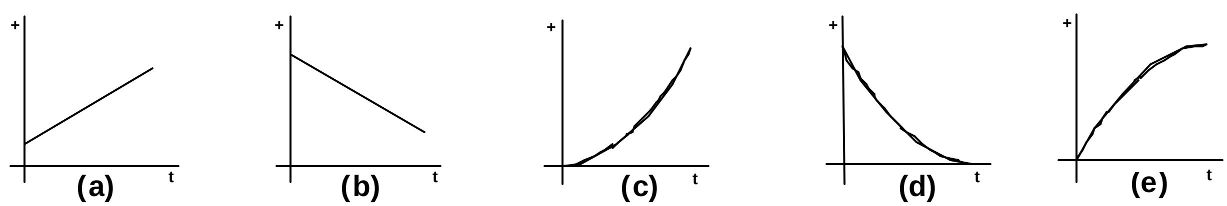
Suppose you are looking down from a helicopter at two cars traveling in the same direction along the freeway. The positions of the two cars every 2 seconds are represented by dots.



24. Which graph below best represents the position-versus-time graph of Car A?

25. Which graph below best represents the position-versus-time graph of Car B?

26. Which graph below best represents the instantaneous velocity-versus-time graph of Car B?

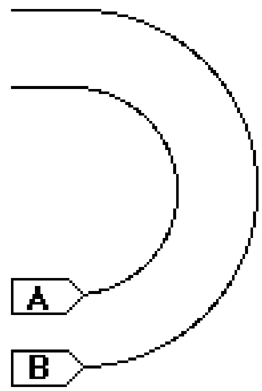


27. You are standing in a hot air balloon which, according to your friend on the ground, is travelling upward at 3.0 m/s. You decide to drop a rock over the side of the balloon. The instant you release the object, your friend determines that the rock is moving with

(a) a velocity of 0 m/s and an acceleration of 9.8 m/s^2 downward.
(b) a velocity of 3.0 m/s upward and an acceleration of 9.8 m/s^2 downward.
(c) a velocity of 0 m/s and an acceleration of 6.8m/s^2 downward.
(d) a velocity of 3.0 m/s upward and an acceleration of 0 m/s^2 downward.
(e) a velocity of 3.0 m/s upward and an acceleration of 3.0 m/s^2 .

Questions 28 - 30 refer to the diagram at right.

Two racing boats go around a semicircular turn in a race course. The boats have the same speed, but boat A is on the inside while boat B is on the outside, as shown in the drawing



28. Which boat gets around the turn in the smaller time?

    (a) A (b) B (c) same time (d) can't tell

29. Which boat has the greater acceleration while in the turn?

    (a) A (b) B (c) same acceleration (d) can't tell

30. At the center of the turn, the acceleration of boat A is?

    (a) 0 (b) → c) ← (d) ↓ (e) ↑