

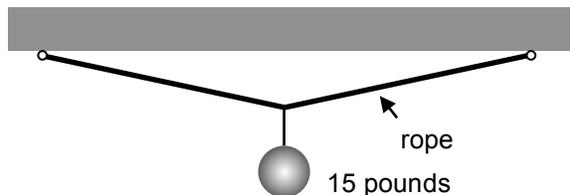
Allowed: calculators, pens, pencils.

Not allowed: books, notes, smart phones, etc.

The exam will end at 1:40 (total time is 65 minutes). 100 total points.

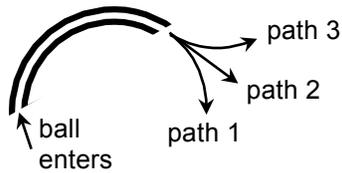
**A. Multiple choice: circle the most appropriate answer (4 points each)**

1. As a baseball pitcher is throwing the ball, and the ball is accelerating in his hand:
  - a. he exerts a force on the ball, but it does not exert a force on him
  - b. he exerts a force on the ball that is greater than its force on him
  - c. he exerts a force on the ball that is less than its force on him
  - d. he exerts a force on the ball that is equal to its force on him
  - e. there is no force on the ball
  
2. A woman stands on a scale in an elevator. When does the scale read the lowest apparent weight? When the elevator is:
  - a. standing still
  - b. is moving upward at constant velocity
  - c. is moving downward at constant velocity
  - d. is accelerating upward
  - e. is accelerating downward
  
3. A disco ball that weighs 15 pounds is hung from the middle of a rope that is attached to the ceiling, as in the diagram. Is the tension in the rope:
  - a. less than 15 pounds
  - b. equal to 15 pounds
  - c. greater than 15 pounds
  - d. it depends on which end of the rope
  - e. tension can't be measured in pounds



4. An ice skater skates at constant speed around a circular rink. Which of the following is correct?
  - a. his acceleration and net force point inward
  - b. his acceleration and velocity point inward
  - c. his net force points outward and velocity points in his direction of travel
  - d. his acceleration is zero
  - e. his net force is zero and velocity points inward

5. A ball is shot out of a curved tube that is lying flat (horizontal) on a tabletop, shown in the diagram. After it leaves the tube, which of the following is correct?
- a. it follows path 1 due to a “memory” of its curved motion
  - b. it follows path 1 due to centripetal force
  - c. it follows path 2
  - d. it follows path 3 due to centrifugal force
  - e. it follows path 3 due to stored outward energy



6. An astronaut accidentally lets go of a hammer while on a spacewalk outside of the International Space Station. What will happen to the hammer?
- a. it will stay next to the astronaut, remaining in orbit around the Earth
  - b. it will fall straight down to Earth
  - c. it will rapidly fly backward, behind the space station
  - d. it will travel in a straight line, taking it deeper into space away from the Earth
  - e. it will slowly drift out to deep space
7. At the Earth’s surface, gravitational acceleration is  $9.81 \text{ m/s}^2$ . What is the gravitational acceleration for a satellite that is in orbit at 6 Earth radii from the center of the Earth? (the height of most cable TV satellites.)
- a. 0
  - b.  $0.272 \text{ m/s}^2$
  - c.  $1.64 \text{ m/s}^2$
  - d.  $9.81 \text{ m/s}^2$
  - e.  $58.9 \text{ m/s}^2$

**Short answer (6 points each)**

8. You want to push a heavy box across a rough floor. By Newton’s third law, your force on the box is equal and opposite to the force of the box on you. Explain how it is possible for you to start the box moving.

9. The diagram shows a girl standing on a spinning merry-go-round. Draw the forces acting on her, drawing vectors from the dashed circle at her center. Label the vectors with as many of the following terms as appropriate: centrifugal force, centripetal force, contact force, gravity, normal force, kinetic friction, static friction.



**Longer answer (10 points each)**

**Give all answers with 3 significant figures and don't forget the units.**

10. A 1200 kg car is traveling at 30 m/s and the driver suddenly slams on the brakes, causing the car to skid to a stop, which takes 3.9 seconds. (a) What is the magnitude of the force acting on the car during the skid? (b) What is the coefficient of kinetic friction between the car tires and the road?

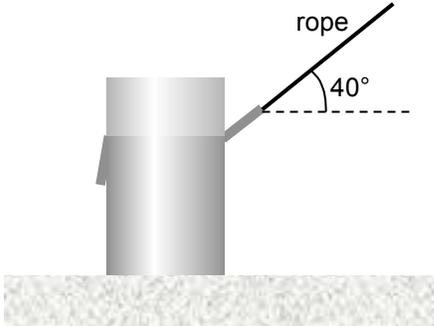
(a)

(b)

11. A 20 kg boy is swinging on a playground swing which has a radius of 3 m. At his lowest point, his velocity is 6 m/s. What is the tension in each of the two chains that hold the swing at this point?

12. How fast (in rpm) must a centrifuge rotate if a particle 8 cm from the axis of rotation is to experience an acceleration of 130,000  $g$ 's?

13. You are using a rope to drag a cooler full of hot chocolate across packed snow at constant velocity. The cooler weighs 20 kg and its coefficient of kinetic friction with the snow is 0.18. The rope has an angle of  $40^\circ$  above horizontal. How much force do you exert on the rope?



14. The sun's mass is  $1.99 \times 10^{30}$  kg and its radius is  $6.96 \times 10^8$  m. (a) Compute the acceleration due to gravity at the surface of the sun. (b) If a man weighs 170 pounds on Earth, what would he weigh on the sun? (1 pound = 4.45 N).

(a)

(b)

15. An airplane flies in a horizontal circle at 118 m/s (it's in a holding pattern). Its banking angle is  $25^\circ$ . (a) What is the radius of the circle? (b) How many times larger is a passenger's apparent weight during the turn than his or her normal weight?