1) You need to make a sharp turn on a flat road, making a radius of curvature of 15 meters. How does the required force of static friction between your tires compare if you make the turn at 30 mph vs. 60 mph?
   A) The force of friction needs to be twice as large.
   B) the force of friction is the same for both speeds since the radius of curvature is the same.
   C) The force of friction needs to be four times as large.
   D) None of the above

2) A person ties a rock to a string and whirls it around in a circle such that sometimes the rock is going straight upward and sometimes the rock is going straight down (the plane of the circle is perpendicular to the horizon). She whirls the rock at the minimum speed (constant in time) such that the string is always taunt (no sag). If she were to use a longer string, she would have to whirl the rock at a
   A) lower velocity.
   B) the same velocity.
   C) higher velocity.

3) A large truck collides head–on with a cyclist. During the collision
   A) the truck exerts the same amount of force on the cyclist as the cyclist exerts on the truck.
   B) the truck exerts a greater amount of force on the cyclist than the cyclist exerts on the truck.
   C) the truck exerts a force on the cyclist, but the cyclist exerts no force onto the truck.
   D) the truck exerts a smaller amount of force on the cyclist than the cyclist exerts on the truck.

4) A piano mover raises a 100 kg piano at a constant rate using a frictionless pulley system, as shown below. With roughly what force is the mover pulling down on the rope?
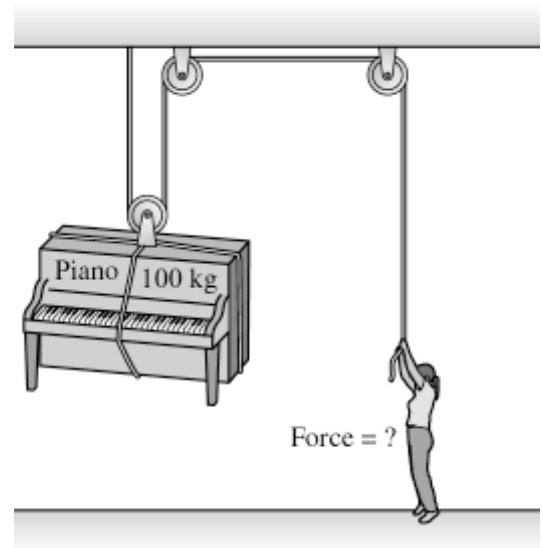

   A) 500 N
   B) 2000 N
   C) 1000 N
   D) 250 N
   E) Depends on the velocity!

5) A star is moving towards the Earth with a speed of $0.9\,c$ (90% the speed of light). It emits light, which moves away from the star at the speed of light. Relative to us on Earth, the speed of the light moving towards us (emitted by the star) is
   A) 1.2 c   B) 0.98 c
   C) 1.9 c   D) c

6) Two friends are standing on opposite ends of a canoe. The canoe is initially at rest with respect to the lake. The person on the right throws a very massive ball to the left, and the person on the left catches it. After the ball is caught, the canoe is (ignore friction between the canoe and the water)
   A) moving to the left.
   B) moving to the right.
   C) stationary

7) A spring–loaded dart gun is used to shoot a dart straight up into the air, and the dart reaches a maximum height of 24 meters. The same dart is shot up a second time from the same gun, but this time the spring is compressed only half as far (compared to the first shot). How far up does the dart go this time (neglect friction and assume the spring obeys Hooke's law)?
   A) three meters   B) 12 meters
   C) 48 meters   D) six meters

8) A person ties a rock to a string and whirls it around in a circle such that sometimes the rock is going straight upward and sometimes the rock is going straight down (the plane of the circle is perpendicular to the horizon). She whirls the rock at the minimum speed (constant in time) such that the string is always taunt (no sag). When is the tension the highest?
   A) The tension is constant as the rock moves around in a circle.
   B) It is highest when the rock is at the lowest elevation.
   C) It is highest when the rock is at the highest elevation.

9) Bill and Susan are both standing on identical skateboards (with really good ball bearings), initially at rest. Bill weighs three times as much as Susan. Bill pushes horizontally on Susan's back, causing Susan to start moving away from Bill. Immediately after Bill stops pushing,
   A) Susan and Bill are moving away from each other, and Susan's speed is three times less than that of Bill.
   B) Susan and Bill are moving away from each other, with equal speeds.
   C) Susan and Bill are moving away from each other, and Susan's speed is three times that of Bill.
   D) Susan is moving away from Bill, and Bill is stationary.

10) You are standing on a skateboard, initially at rest. A friend throws a very heavy ball towards you. You can either catch the object or deflect the object back towards your friend (such that it moves away from you with the same speed as it was originally thrown). What should you do in order to minimize your speed on the skateboard?
   A) catch the ball
   B) Your final speed on the skateboard will be the same regardless whether you catch the ball or deflect the ball.
   C) deflect the ball

11) Joe and Bill throw identical balls vertically upward. Joe throws his ball with an initial speed twice as high as Bill. The maximum height of Joe's ball will be
   A) two times that of Bill's ball.
   B) four times that of Bill's ball.
   C) roughly 1.3 times that of Bill's ball.
   D) equal to that of Bill's ball.
   E) eight times that of Bill's ball.

12) An astronomer on earth sees a meteor hit the Moon at exactly the same time as he sees a solar flare erupt on the sun. The solar flare and the meteor impact are simultaneous events in this astronomer's reference frame.

13) In their common rest frame, two stars are 90.0 ly apart. If they appear to be 42.1 ly apart to a spaceship, how fast is the spaceship moving? Express your answer in terms of c.
   A) 0.823 c   B) 0.884 c
   C) 0.845 c   D) 0.865 c

14) The figure shows a 3.0 kg ball tied to the end of a 50 cm long string being swung in a circle in a vertical plane at constant speed. The center of the circle is $h = 230$ cm above the floor. The ball is swung at the minimum speed necessary to make it over the top without the string going slack. If the string is released at the instant the ball is at the top of the loop, how far to the right of the center of the circle does the ball hit the ground?
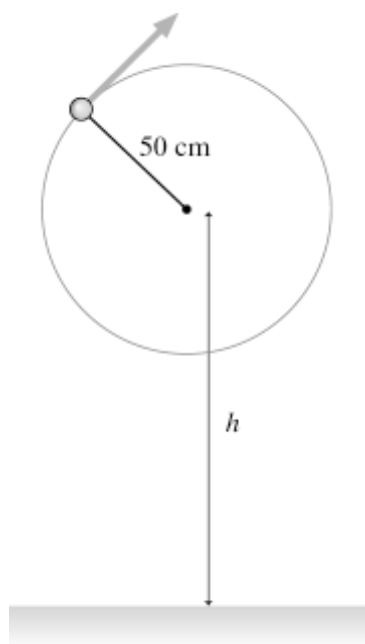
A) 170 cm   B) 130 cm
C) 150 cm   D) 0.0 cm

15) A 100 g ball of clay is thrown horizontally with a speed of 90.0 m/s toward a 900 g block resting on a frictionless surface. It hits the block and sticks. The clay exerts a constant force on the block during the 10.0 ms it takes the clay to come to rest relative to the block. After 10.0 ms, the block and the clay are sliding along the surface as a single system. What is the force of the clay on the block during the collision?
    A) 4050 N   B) 8100 N
    C) 810 N   D) 900 N

16) A child swings a 0.37 kg ball in a circle on a string that is 1.3 m long. If the ball makes 1.2 rev/s, what is the magnitude of the ball's angular momentum?
    A) 0.8 kg·m²/s   B) 5.2 kg·m²/s
    C) 3.7 kg·m²/s   D) 4.7 kg·m²/s

17) An object attached to a spring is pulled across a frictionless surface. If the spring constant is 45 N/m and the spring is stretched by 0.88 m when the object is accelerating at 2.0 m/s², what is the mass of the object?
    A) 20 kg   B) 26 kg
    C) 22 kg   D) 17 kg

18) A new roller coaster contains a loop-the-loop in which the car and rider are completely upside down. If the radius of the loop is 12.6 m, with what minimum speed must the car traverse the loop so that the rider does not fall out while upside down at the top? Assume the rider is not strapped to the car.
    A) 14.9 m/s   B) 11.1 m/s
    C) 12.2 m/s   D) 10.1 m/s

19) A 18.7 kg child must exert a 350.0 N radial force in order to remain on her mount on the outer edge of a merry-go-round. Assuming that the child is moving at 8.00 m/s, what is the diameter of the merry-go-round?
    A) 6.84 m   B) 3.42 m
    C) 7.11 m   D) 3.56 m

20) If you swing a bucket of water fast enough in a vertical circle, at the highest point the water does not spill out because an outward force balances the pull of gravity on the water.

21) You pull on a crate with a rope. If the crate moves, the rope's pull on the crate must have been larger than the crate's pull on the rope, but if the crate does not move, both of these pulls must have been equal.

22) In a ballistics test, a bullet traveling horizontally strikes and embeds itself in a large block which is free to move. During this process, the bullet transfers all of its momentum to the block.

23) As a box slides along a rough horizontal surface and comes to rest, its kinetic energy is transformed into potential energy.

1) C
2) C
3) A
4) A
5) D
6) C
7) D
8) B
9) C
10) A
11) B
12) FALSE
13) B
14) A
15) C
16) D
17) A
18) B
19) A
20) FALSE
21) FALSE
22) FALSE
23) FALSE