Physics 101 Exam 1

September 16, 2002

GOLD VERSION

Select the single best answer for each question, unless otherwise instructed. No notes or calculators are permitted.

$g = 9.8\ \text{m/s}^2$ $\pi = 3.14$ $2^{1/2} = 1.41$

1. To get the maximum distance from a football kick, you should kick the ball at an upward angle of

(a) 30 degrees. (b) 45 degrees. (c) as low as possible. (d) as vertical as possible.

To obtain the maximum horizontal distance in projectile motion, the optimal launch angle is **(b) 45 degrees**.

2. If you are in a train moving at 80 miles per hour on a straight track and throw a ball straight up, it will land

(a) at the same spot you threw it (b) behind you (c) in front of you

The train is an inertial reference frame, meaning that the physics on the frame is the same as at rest. No horizontal force would act on the ball, because there is no acceleration in that direction. Therefore, the ball will land at **(a) the same spot where you threw it up**. Note that the problem said "in" the train, not "on top of" the train: air resistance is not a factor in where the ball lands.

3. An apple falls from a branch 9.8 m above the ground. It hits the ground in

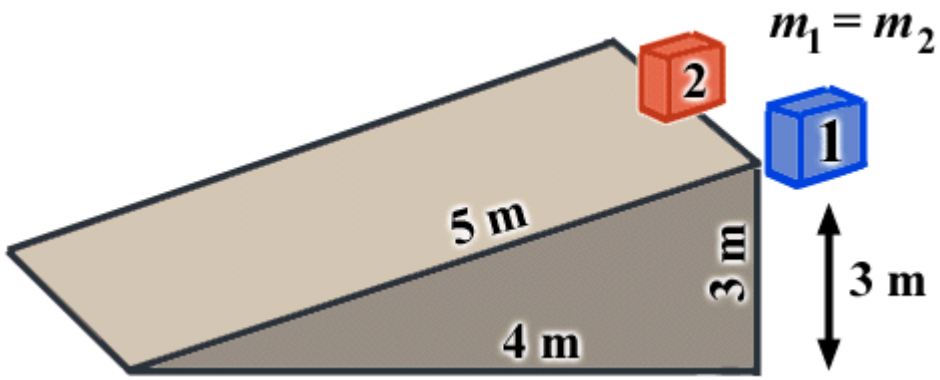
(a) 2.0 s (b) 9.8 s (c) 1.4 s (d) 1.0 s

The distance the apple falls is $h = \frac{1}{2} g t^2$, so that 9.8 m = ½ (9.8 m/s^2) t^2. Solving for t^2 gives = 2 s^2, or t = **1.4 s**. The answer is **(c)**.

4. If a figure skater pulls her arms in while spinning so that she spins twice as fast, which of the following is true?

(a) Her angular momentum doubles and her rotational kinetic energy is conserved.
(b) Her moment of inertia is conserved and her rotational kinetic energy increases.
(c) Her moment of inertia is half as big, and her rotational kinetic energy doubles.
(d) Her moment of inertia is half as big, and her rotational kinetic energy is conserved.

Her angular momentum $L = I \omega$ is conserved. Since the angular velocity ω doubles, the moment of inertia I must be **half** as much as before. Her rotational kinetic energy is ½ $I \omega^2$. Since I is now half as big and ω is twice as big, her kinetic energy doubles. This means it requires work to pull her arms in, since her rotational energy increases.
The answer is **(c)**.



5. Two boxes are initially 3 meters above the ground. Box 1 is dropped, and Box 2 begins to slide down a frictionless ramp at the same time. Which box is moving faster when it gets to the ground ?

(a) The speeds are the same. (b) Box 1 (c) Box 2

In either case, the final kinetic energy equals the initial potential energy. Since the initial potential energies (mgh) are equal, the final kinetic energies are also equal. This implies that **(a)** the final speeds are **the same**.

6. In problem 5, Box 1 reaches the ground

(a) in 3/5 the time that Box 2 does.
(b) at the same time as Box 2.
(c) in 9/25 the time that Box 2 does.
(d) in 4/5 the time that Box 2 does.

Using the mechanical advantage factor for a ramp shows that the force on Box 2 is 3/5 as big along the ramp as the downward force on Box 1. The acceleration of Box 1 is *g*. Therefore, the acceleration of Box 2 down the ramp is 3*g*/5. Since the final speeds are equal, this means it taxes Box 1 **3/5** as long to arrive at that speed as Box 2, using $v = at$. The answer is then **(a)**.

7. If a wheel rotates 30 times in a minute, its angular velocity is most nearly

(a) 0.5 rad/s (b) 2.0 rad/s (c) 3.1 rad/s (d) 15 rad/s

The angular velocity is $\omega = 30$ rev/min $= 30 \times 2\pi$ rad / 60 sec = $\boldsymbol{\pi}$ **rad/s**, or **(c)**.

8. Suppose Ball 1 weighs 250 g and ball 2 weighs 500 g. Both balls roll off a table at the same speed. Which ball lands closer to the table?

(a) The lighter ball 1 will land much closer to the edge of the table.
(b) The two balls will land about the same distance from the table.
(c) The heavier ball 2 will land much closer to the edge of the table.
(d) You cannot say without knowing the balls' moments of inertia.

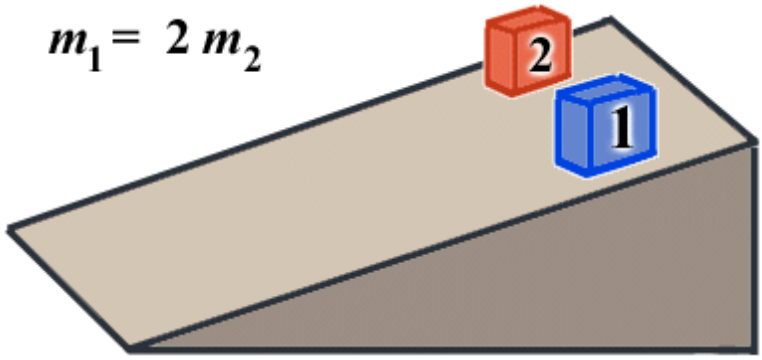
Both balls will fall at the same rate, because gravity affects them both the same way. Therefore, they will hit the ground at the same time. In that time, they will travel **the same** horizontal distance, because they are moving with the same initial velocity, and there is no horizontal force on them after they leave the table. Their moments of inertia are relevant only to their rotational motion, which affects how much work it takes to get them started rolling, but has no effect on the motion once they leave the table. The correct answer is therefore **(b)**.

9. A train accelerates at 0.4 m/s^2. How long will it take to reach a cruising speed of 72 km/h?

(a) 50 s (b) 72 s (c) 36 s (d) 100 s

First, convert units: 72 km/h = 72,000 m / 3,600 s = 20 m/s. The time is then $t = v/a$ = 20 m/s / 0.4 m/s^2 = **50 s**. The answer is **(a)**.

10. Two boxes are identical, except that box 1 is twice as heavy as box 2. They are both sitting at the same height on a ramp.



Which of the following statements is true?

(a) The frictional force on both boxes is the same.
(b) The frictional force on box 1 is twice as much as on box 2.
(c) The frictional force on each box is at least as large as its weight.
(d) The gravitational potential energy of both boxes is the same.

The frictional force is proportional to the force pressing the two objects together. In this case, that force is the normal force holding the box up, which is proportional to the weight of the box. Since box 1 is twice as heavy, it feels **twice as much friction**. You could also compare the forces pulling the boxes down the ramp, which must balance the friction by Newton's Third Law. These forces are equal to the weights of the boxes times the mechanical advantage factor for the ramp. Either way, the answer is **(b)**.

11. If the ramp is made steep enough, the boxes will start to slide. Which box will reach the bottom of the ramp first?

(a) Neither box, because they have the same acceleration.
(b) Box 1, because it is heavier.
(c) Box 2, because it has less inertia.
(d) It depends on how steep the ramp is.

The force pulling the boxes down the ramp is now greater than the friction, so they accelerate. Since the both of these forces is proportional to the mass, the net force is also proportional to the mass of the box. Since $F = ma$, the acceleration of each box is **the same**. The answer is **(a)**.

12. You drive on a circular track at a speed of 120 miles per hour. When you make one lap and return to your starting point, which of the following **does not** apply?

(a) Your average velocity was zero.
(b) Your average acceleration was zero.
(c) Your velocity was constant.
(d) Your acceleration was perpendicular to your velocity.

Since your direction was constantly changing, you were accelerating for the whole trip. Your velocity was constantly **changing**. The acceleration was toward the center of the circle, which is perpendicular to your direction of motion. Your average velocity and acceleration were both zero, because the direction pointed all different ways as you went around the circle, averaging out to zero. Only **(c)** does not apply.

13. You exert a force of 200 N to push a box 10 m across a floor at constant velocity. Which of the following **is true**?

(a) The kinetic energy of the box increased.
(b) The net force on the box was 200 N.
(c) The thermal energy of the box increased.
(d) You did no work on the box.

Since the velocity was constant, the kinetic energy was constant. The net force on the box was zero because it was not accelerating. (Your force was balanced by friction.) The **thermal energy of the box increased** due to friction. You did work on the box, which went into producing heat through friction. The only true answer is **(c)**.

12. If a solid ball and a hollow ball of the same mass and diameter roll down a hill from the same starting height, which will get to the bottom first?

(a) The hollow one. (b) The solid one. (c) They arrive together.

The ball with the smaller moment of inertia will accelerate faster. The solid ball has more of its mass close to the center, and the total masses are the same, so the solid ball has a smaller moment of inertia. That means the **(b) solid ball** will accelerate faster.

15. You throw an orange high above your head. **After** it leaves your hand, it will experience…

(a) both an upward and downward force, but the upward force will gradually diminish with height.
(b) an upward force as it rises and a downward force as it falls.
(c) the downward force of its weight.
(d) the downward force of its weight as its rising, then no force while it is in free-fall.

After the ball leaves your hand, the only force acting on it is the **downward force of gravity**, which is its weight. It moves upward due to inertia, which is not a force. The answer is **(c)**.

16. When your car suddenly turns to the right, loose objects on the dash start sliding to the left. Neglecting friction against the dashboard, these objects are…

(a) accelerating to the left
(b) releasing thermal energy
(c) moving at a constant velocity in their original direction

The objects are **(c) moving at a constant velocity in their original direction**, due to inertia. The car is accelerating, but not the objects on the dashboard.

17. If Ball 1 is dropped from twice as high as Ball 2, then Ball 1 lands with

(a) twice the kinetic energy of Ball 2.
(b) four times the kinetic energy as Ball 2.
(c) about 1.4 times the kinetic energy as Ball 2.

The final kinetic energy of either ball is equal to its initial potential energy, which is *mgh*. Therefore, the final kinetic energy is proportional to the height from which the ball is dropped. If Ball 1 falls from twice as high as Ball 2, it lands with **(a) twice** the kinetic energy.

18. You are cutting wood with a hand saw and have to push it away from you, then pull it back as you cut. When are you doing positive work on the saw?

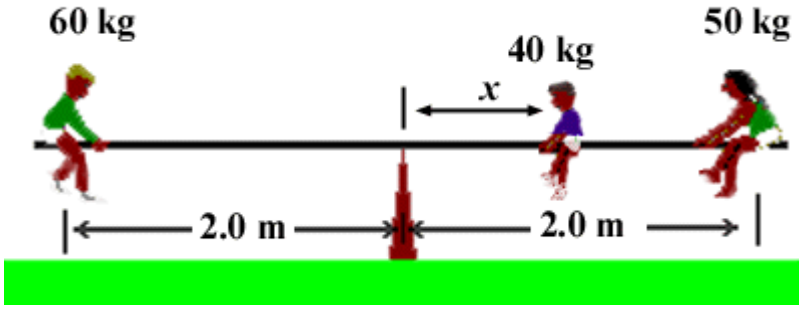
(a) Only when pushing it away.
(b) Only when pulling it.
(c) Both when pushing it away and pulling it toward you.
(d) You are not doing work on the saw. It is doing work on you.

You do positive work on the saw whenever the force you put on it is in its direction of motion. This is true whether you are **pushing it away** or **pulling it toward** you, so the answer is **(c)**.

19. If your mass is 60 kg and you sit on the left side of a seesaw, 2 m from the center, how much torque do you exert on the see-saw? Select the **closest** answer.

(a) 120 N m clockwise
(b) 2400 N m counter-clockwise
(c) 120 N m counter-clockwise
(d) 1200 N m counter-clockwise

Torque is the length of the lever arm times the perpendicular force. In this case, the force is mg = 600 N, rounding g to 10 m/s^2. The lever arm is 2.0 m from the center. This gives a torque of **(d) 1200 N m** in the counter-clockwise direction (since you are pushing down to the left).



20. If a 40 kg person and a 50 kg person sit on the other side of the seesaw as shown, so that it is balanced, the distance x shown in the figure is **most nearly**

(a) 1.7 m (b) 1.3 m (c) 1.0 m (d) 0.5 m

The torque due to the person on the left is 60 kg x 2.0 m x g = (120 kg m) g counter-clockwise. The torque due to the person at the far right is 50 kg x 2.0 m x g = (100 kg m) g clockwise. This makes a net torque of (20 kg m) g counter-clockwise. To balance this, the 40 kg person must sit **0.5 m** right of the pivot, creating a clockwise torque of (20 kg m) g. The answer is **(d)**.