PART I: Multiple choice questions

Only one of the choices given is the correct answer. No explanation for your choice is required. Each multiple choice problem is worth 5 points.

1. Microwaves in a microwave oven can cause the water molecules in your burrito to vibrate, thereby heating it. If the frequency of microwaves used in a microwave oven is 10 GHz, what is their wavelength?

(a) 0.3 mm

(b) 3 cm

(c) 30 cm

(d) 300 m

(e) 3 km

2. You hear a fire truck with a certain intensity, and you are about 1 mile away. Another person hears the same fire truck with an intensity that is about 10 times less. Roughly how far is the other person from the fire truck?

(a) about the same distance

(b) about 3 miles

(c) about 10 miles

(d) about 30 miles

(e) about 100 miles

3. A space probe enters the thin atmosphere of a planet where the speed of sound is only about 45 m/s. If the speed of the probe is 15,000 km/hr, what is the angle of shock wave relative to the direction of motion?

(a) about 0.00009 degrees

(b) about 0.6 degrees

(c) about 3 degrees

(d) about 30 degrees

(e) about 97 degrees

(f) about 99.7 degrees

4. Which of the following will result in the formation of a real image?

(a) a converging lens with an object placed inside its focal length

(b) a converging lens with an object placed outside its focal length

(c) a diverging lens with an object placed inside its focal length

(d) a diverging lens with an object placed outside its focal length

5. If you stand in front of a flat mirror, how tall does the mirror have to be so that you can see yourself entirely? (Assume the bottom of the mirror can be placed at any convenient height.)

(a) exactly the same as your height

(b) your height minus the distance from the top of your head to your eyes

(c) half of your height plus half the distance from the top of your head to your eyes

(d) exactly half of your height

(e) half of your height minus half the distance from the top of your head to your eyes

(f) it depends on what distance you stand from the mirror

6. A pipe organ has pipes that are closed at one end and open at the other end. Which of the following frequencies would you not expect to hear produced by an organ pipe of length 50 cm? (Assume that the air in and around the pipes is at room temperature.)

(a) 172 Hz

(b) 343 Hz

(c) 515 Hz

(d) 858 Hz

PART II: Short problems

To earn full credit on the following problems, you must exhibit the steps that lead to your final result. Problem 7 is worth 40 points, and problems 8 and 9 are worth 15 points each.

7. The following is an excerpt from Part 571.111 of the Federal Motor Vehicle Safety Standards, which specifies the legal requirements for convex mirrors on vehicles in the US:

S5.4.2 Each convex mirror shall have permanently and indelibly marked at the lower edge of the mirror's reflective surface, in letters not less than 4.8 mm nor more than 6.4 mm high the words "Objects in Mirror Are Closer Than They Appear."

S5.4.3 The average radius of curvature of each such mirror shall be not less than 889 mm and not more than 1,651 mm.

(a) A vehicle has a "sideview" convex mirror on the passenger side. What are the minimum and maximum magnifications allowed by law for objects that are 3 meters away from the mirror?

(b) For a convex mirror with radius of curvature equal to 1 meter, how far in front of the mirror would an object need to be in order for it to appear to be one third of its actual size?

(c) If you are sitting in a parked car looking through a sideview convex mirror at another car that is traveling directly towards you at speed v_o, how fast will the virtual image of the other car in the mirror be approaching? Determine the image speed v_i as a function of the radius of curvature, R, of the mirror and the distance to the other vehicle, x.)

(d) Which is closer to a convex mirror: an actual object, or the virtual image of that object when viewed through the mirror?

(e) Which concept does a better job of explaining the mandatory statement described in S5.4.2—virtual image distance or magnification?

8. A flute is designed to play middle C (262 Hz) as the fundamental frequency at a temperature $T = 20°$ when all the holes are covered. What beat frequency will be heard if two identical flutes, each 0.66 m long play a middle C, if one flute is played at 5.0° C and the other is played at 28° C?

9. A diverging lens with focal length $f = -33.5$ cm is placed 14.0 cm to the right of a converging lens with $f = 20.0$ cm. A light source, infinitely far away to the left of the two lenses, is located on the axis of the lenses. At what point will an object at infinity be focused?