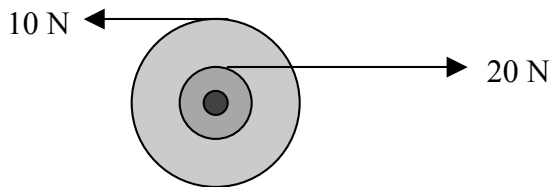


## PHYS 250 Final Exam Review Problems

For each problem, **first** identify the concept(s) involved (e.g., conservation of momentum, Newton II, kinematics (x-v-a relationships), Archimedes, Work-energy, torque, pressure, Newton III, etc).

Use speed of sound = 343 m/s, speed of electromagnetic waves  $c = 3 \times 10^8$  m/s

- 1) A box is initially at rest, but a child pushes on the box with a force of 30 N and gets the box up to a speed of 5 m/s in 4 seconds. Friction exerts a 10 N force (what kind of friction?) on the box. What is the mass of the box?
- 2) A person sitting on a tree branch drops a 0.05 kg pebble and it lands in 0.8 second. The person then throws a 0.07 kg pebble horizontally and it lands 5 meters away. How fast did the person throw the pebble?
- 3) A beach ball ( $m = 0.15$  kg,  $r = 0.3$  m) is pushed all the way below the surface of a pool of water ( $\rho = 1000$  kg/m<sup>3</sup>) and released. What is the acceleration of the beach ball the *instant* it is released? (Do you think friction between the water and the ball will be important once the ball starts moving?)
- 4) A 60 kg person is standing on a 10 kg block of wood that is on a frictionless floor. The person jumps forwards with a horizontal speed of 10 m/s, pushing on the block for 2 seconds. What is the speed of the block? (Part B: If the floor has friction and the maximum static frictional force on the block of wood due to the floor during this time is 50 N, does the block slide backwards?)
- 5) An axle has attached to it two discs – one has a radius of 0.05 meters and the other has a radius of 0.15 meters. If a 20 N tension rope pulls on the 0.05 meter disc and a 10 N tension rope pulls on the 0.15 meters disc (see diagram), what is the angular acceleration  $\alpha$  of the axle ( $I = 3$  kg m<sup>2</sup>)?



- 6) Three blocks sliding on frictionless ice collide and move off together at  $v_x = 5$  m/s. If the first block has a mass of 5 kg and an initial velocity of  $v_x = 3$  m/s, and the second block has a mass of 3 kg and an initial velocity of  $v_x = 2$  m/s and  $v_y = 2$  m/s, what was the initial velocity of the third mass ( $m = 4$  kg)?
- 7) In an episode of Mythbusters!, they examined whether someone could avoid being shot by a bullet by diving into water. Surprisingly, the answer was yes, because the bullet lost all its kinetic energy by a depth of 1 meter. If the bullet had a mass 0.05 kg and a speed of 500 m/s, what was the average force on the bullet due to the water?
- 8) In class we discussed “the restaurant experiment” (keeping water in a straw by putting our finger over the top of the straw). What’s the greatest theoretical possible height of water we can hold in a straw this way? (Hint: what would be the pressure at the top of the straw for this case?)

9) A 10 kg object moving at 4 m/s collides with a stationary 5 kg object. The 10 kg object stops and the 5 kg object moves in the same direction at 8 m/s. Is this possible? Why or why not?

10) A mass-spring simple harmonic oscillator has a frequency of 2 Hz and an amplitude of 0.1 m. What is the new frequency if someone comes along and gives it a kick so that the amplitude is now 0.2 m? What is the new frequency if someone doubles the mass hanging on the spring?

11) A block of mass  $m$  sits on a horizontal surface. Someone pushes vertically down on the center of the block with a force  $F_{\text{push}}$ . What is the apparent weight of the block?

12) What must be the tension in a 0.1 m string ( $\mu = 0.02$  kg/m) if its fundamental frequency is 220 Hz?

13) You are lifting weights and lift 50 kg (about 100 lbs) a distance of 0.6 meters 50 times. How many Calories (food ones = 4186 J) do you “burn”? (Use an efficiency of the human body of 25%.)

14) A simple pendulum (mass on a string) originally had a period of 1 second. Over time, however, the string stretched a bit (so it's about 2% longer now) due to the weight hanging from it. Does the pendulum run fast or slow? What is the new period?

15) You are holding a pencil in one hand. You are holding the pencil near the eraser, with your index finger pushing up on the pencil just where the metal (the eraser holder) and wood (the pencil itself) meet, and your thumb pushing down on the end of the eraser. If the pencil has a weight of 0.2 N, estimate the force your index finger exerts to hold up the pencil.

16) You are racing a wave in a string with sound. The string has  $\mu = 0.05$  kg/m. What tension do you need in the string so that a pulse in the wave travels as fast as sound in air?

17) The new Wii Fit balance board uses force sensors to determine where your center of mass is (at least the horizontal position) from your weight distribution. Let's simplify the system to two sensors located 0.3 meters apart. If the left sensor reads 75 N and the right sensor reads 250 N, where the center of mass of the person? (And how much does the person weigh?)

18) You are swinging a ball tied to a string around in a circle of radius  $r$ . At one instant, the ball is moving at speed  $v$  and the string is vertical (downwards; that is, the ball is below your hand). What is the tension in the string? Does it change when the string is vertically upwards (ball at the top)?

19) What is the frequency emitted by a microwave oven? (typical wavelength is about 12 cm)

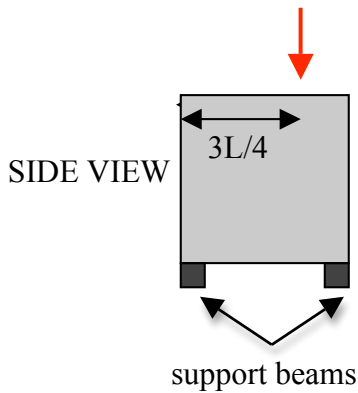
20) You are holding a book (mass  $m$ ) at rest in your hand. A moment later you are lifting the book at a constant speed  $v$ . How much more force is your hand exerting on the book in lifting the book at constant speed than in holding the book at rest?

21) What fundamental frequency is emitted by an open-open tube with length 24 cm? How does the answer change if one end is closed?

22) A pop-up toy's spring releases. The toy has a mass 50 g. If the toy's velocity changes from 0 m/s to 6 m/s in 0.1 seconds, how hard on average does the toy push on the table during this time?

23) A 2 kg mass oscillates on a 500 N/m spring with an amplitude of 0.05 meters. What is the maximum speed of the mass? Where in the cycle does that occur?

24) The a 10 kg block (a cube of length L) is supported on each end by a narrow beam. Someone pushes down on the block with a force of 50 N on the point shown. What is the force exerted by each support beam?



25) You make a square with four toothpicks and then remove the toothpick forming the right side (so there is still a left, top, and bottom side). Where is the center of mass of the three remaining toothpicks?

26) You are holding a 5 kg mass in your hand. Your arm has a length of 0.8 meters and a mass of 7 kg. Your arm is straight and is horizontal. (a) What is the torque due to gravity on the arm around the shoulder? (b) Estimate the force exerted by your deltoid muscles to support your arm (and mass in your hand).

27) What is the buoyant force on a 5 kg object completely submerged in water if it has twice the density of water? What is the buoyant force on a 5 kg object floating on water if it has  $3/4$  the density of water?

28) What is the acceleration of the masses in the system below? What are the tensions in the ropes?

