

Physics@Mac Online Physics Competition  
December 1, 2016

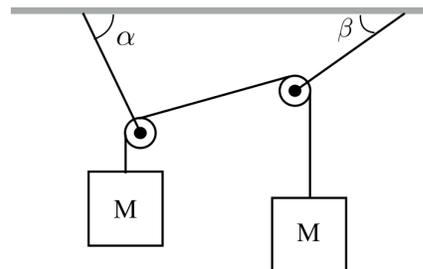
1. Roughly how many people in the world are on their cell phones right now?

- a)  $10^6$
- b)  $10^8$
- c)  $10^{10}$
- d)  $10^{12}$

2. A box of mass  $m$  is dragged by a horizontal force  $F$  a distance  $d$  along a surface with coefficient of kinetic friction,  $\mu_k$ , then dragged back along the same path to its original position, the work done by friction is:

- a)  $-2\mu_k mgd$
- b)  $2\mu_k mgd$
- c)  $-2Fd$
- d) 0

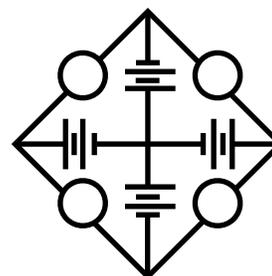
3. Two equal masses hang from a pulley system as shown. The pulleys are attached to the ceiling with ropes that are the same length. Assuming that the pulleys are frictionless and the ropes are massless, in static equilibrium what are the angles  $\alpha$  and  $\beta$ ?



- a)  $\alpha = \beta = 60^\circ$
- b)  $\alpha = \beta = 45^\circ$
- c)  $\alpha = \beta = 30^\circ$
- d)  $\alpha > \beta$  and remains as shown in the picture

4. The circuit to the right has four identical batteries (indicated by the short parallel lines) and four identical light bulbs (indicated by the circles). The current in each bulb is  $I_L$ . The current provided by each battery is  $I_B$ . Which of the following is true:

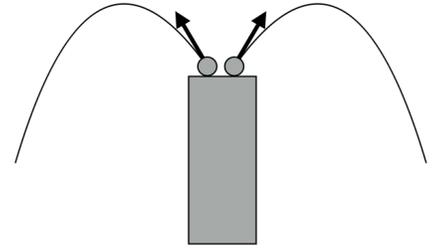
- a)  $I_B = I_L = 0$
- b)  $I_B = I_L \neq 0$
- c)  $I_B > I_L$
- d)  $I_B < I_L$



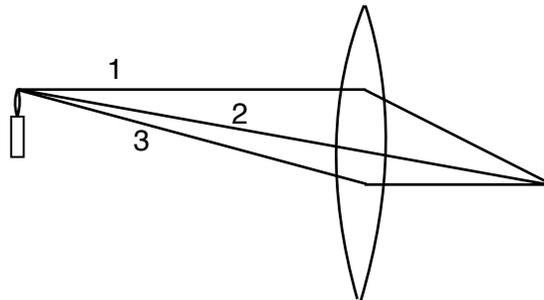
5. Suppose rain falls vertically into an open train car rolling along a straight horizontal track with negligible friction. As a result of the accumulating water:

- a) The momentum and kinetic energy of the train car increase.
- b) The momentum and kinetic energy of the train car decrease.
- c) The momentum and kinetic energy of the train car remain the same.
- d) The momentum remains the same and kinetic energy decreases.

6. Two balls are shot off a rooftop at the same time. They have the exact same initial speed, and same angle from the horizontal, but in opposite directions as shown (the vertical component of the velocity is the same, and the horizontal components differ only by a negative sign). What can you say about the total distance between the two balls? [Assume air resistance is negligible]



- a) The distance between the balls remains constant as they fall.  
 b) The distance between the balls increases at a constant rate.  
 c) The distance between the balls decreases at a constant rate.  
 d) The distance between the balls increases, but the rate is not constant.
7. Photons 1, 2 and 3 leave the top of a candle flame at the same moment and follow the respective paths shown in the diagram to form an image. Which photon arrives at the image first? (Note  $c = 3 \times 10^8$  m/s)



- a) 1  
 b) 2  
 c) 3  
 d) All arrive at exactly the same moment.
8. The volume of liquid flowing per second is called volume flow rate,  $Q$ , and has the dimensions of  $[L]^3/[T]$ . The flow rate of liquid through a hypodermic needle during an injection can be estimated with the equation shown below. The length and radius of the needle are  $L$  and  $R$ , respectively both of which have the dimension  $[L]$ . The pressures at opposite ends of the needle  $P_2$  and  $P_1$ , both which have dimensions of  $[M]/([L][T]^2)$ .  $\eta$  is the viscosity of the liquid and has dimensions of  $[M]/([L][T])$ . Using dimension analysis, what is the value of  $n$  in the expression for  $Q$

$$Q = \frac{\pi R^n (P_2 - P_1)}{8\eta L}$$

- a) 1/2  
 b) 1  
 c) 4  
 d) 5
9. You are sitting in a wagon that is being pulled northward at a constant velocity along a horizontal sidewalk. You are not using your hands to hold on to any part of the wagon, you are just sitting in the wagon and travelling at the same constant velocity as the wagon. Which of the following is a correct list of all the forces acting on you? Neglect air resistance.
- a) gravity down, normal force up, and static friction northward  
 b) gravity down, normal force up, and static friction southward  
 c) gravity down, normal force up, and kinetic friction northward  
 d) gravity down and normal force up

10. Two identical glass slides in air are illuminated from the top with monochromatic light. The slides are exactly parallel with a very thin air gap between them, and the top slide is moving slowly upward. What do you see in top view?

- a) all dark
- b) all bright
- c) fringes moving apart
- d) alternating dark and bright

