Phys 170 Final Exam

Time limit: 120 minutes

Each question worths 10 points.

Constants: $g = 9.8m/s^2$, $G = 6.67 \times 10^{-11} Nm^2kg^{-2}$.

M_E	$5.975 \times 10^{24}kg$	M_M	$7.35 \times 10^{22}kg$	M_S	$1.987 \times 10^{30}kg$	R_{EM}	$3.85 \times 10^{8}m$
R_E	$6.371 \times 10^{6}m$	R_M	$1.74 \times 10^{6}m$	R_S	$6.96 \times 10^{8}m$	R_{ES}	$1.5 \times 10^{11}m$

R_E, R_M, R_S: Radius of the Earth, the Moon, and the Sun.
R_{EM}, R_{ES}: Mean center-to-center distances from the Earth to the Moon and to the Sun.

1. (a) Give the definition of (using equations or in words) (i) pressure; (ii) density. (b) What is the Archimedes' Principle? (c) Use this principle to explain why it is easier to float on salty water (such as the Dead Sea) compared with fresh water.

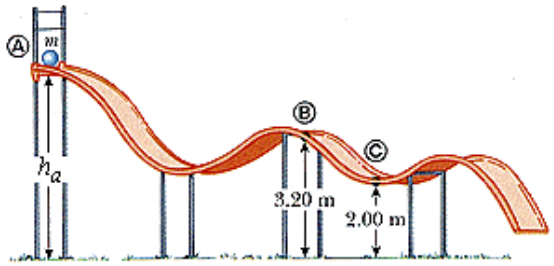
2. A wave is described by $y = 3\sin(2x - 10t)$ in SI units. (a) Determine the (i) amplitude, (ii) wavelength, (iii) frequency, (iv) the direction of the wave, and (v) speed of the wave. (b) Find the transverse velocity of the wave for the position $x = 2m$ at time $t = 3s$.

3. A simple harmonic oscillator takes $12s$ to undergo four complete vibrations. (a) Find the period of its motion. (b) Find the frequency. (c) Find the angular frequency.

4. A satellite of mass $230kg$ is in a circular orbit of radius $r = 3R_E$ around the Earth. [The value of R_E, the radius of the earth, is given at top of the first page.] (a) Find the satellite's angular velocity. (b) What is its period? (c) Calculate the gravitational force acting on it.

5. An object of mass $m = 7.00kg$ is released from point A and slides on the track shown in Figure 1. ($h_a = 6.00m$). The moment of inertia of a sphere is $I_{sphere} = \frac{2}{5}mR^2$. (a) Determine the object's speed at points C if the object *slides* down and the track is frictionless (no need to do point B). (b) Determine the object's speed at point C if the object *rolls* down instead (no need to do point B). [You will lose most of the points of this question if you mix up part (a) and (b). Label which case you are doing clearly in your solution.]

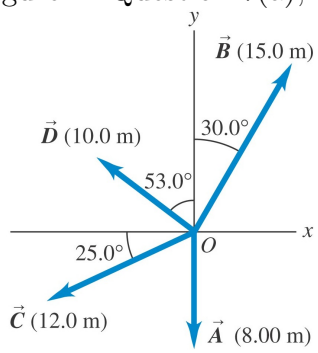
Figure 1: Question 5



6. A toy car of mass $m_1 = 6kg$ moving at speed $5m/s$ to the right collides with another toy car of mass $m_2 = 3kg$ moving at speed $12m/s$ to the left. The two cars stick together after the collision and move with the same speed in the end. (a) Find the final velocity after the collision. (b) Find the change in kinetic energy.

7. Figure 2 shows four vectors and their magnitudes. You can ignore vectors $\vec{B}$ and $\vec{C}$ for this problem. (a) Write down the vectors $\vec{A}$ and $\vec{D}$ (separately, not the sum) in $\hat{i}$, $\hat{j}$ notation. (b) For the vector $\vec{A} - \vec{D}$, find: (i) the magnitude; and (ii) the angle.

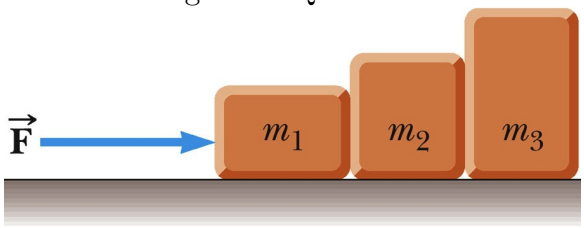
Figure 2: Question 7(a), (b)



8. A $15.0kg$ block is dragged over a rough, horizontal surface by a $73.0N$ force acting at 20.0° above the horizontal. The block is displaced $7.00m$, and the coefficient of kinetic friction is 0.300. (a) Draw the force diagram. If your diagram is incorrect, you will lose most of the points of the subsequent parts. (b) Find the work done on the block by the $73.0N$ force. (c) Find the work done on the block by the normal force. (d) Find the work done on the block by the gravitational force. (e) Find the value of the force of friction. (You do not need to compute the work done by friction.)

9. Three blocks are in contact with one another on a frictionless, horizontal surface as shown in Figure 3. A horizontal force is applied to m_1. Contact force between the m_1 and m_2 is F_{12} and the contact force between the m_2 and m_3 is F_{23}. (a) Taking $m_1 = 1.00kg$, $m_2 = 2.00kg$, $m_3 = 3.00kg$, and $F = 24.0N$, draw a separate free-body diagram for each block (no need to show the vertical forces). Don't forget to label the contact forces F_{12} and F_{23} in your diagrams. Since the force diagrams underpin the logic of the solution, you must give the correct diagrams to receive any credits for the rest of the question. (b) Write down three equations using Newton's Laws (one for each diagram). (c) *Solve the three equations* to find the acceleration. No points will be given if your answer does not result from the three equations. (d) Find F_{23}. (e) Find F_{12}.

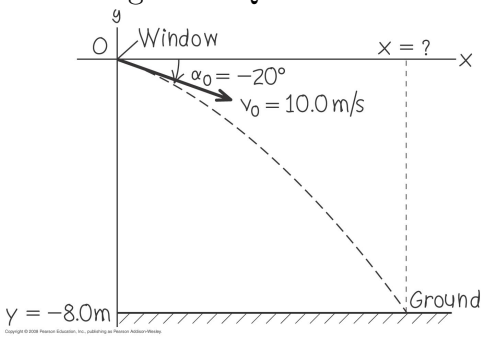
Figure 3: Question 9



10. Figure 4 shows a ball thrown from a window $8m$ above ground, with a speed of $10m/s$ at an angle of 20° below the horizontal. (a) Find the time when the ball hits the ground. (b) Find the horizontal distance x the ball travels before hitting the ground.

11. The driver of a car slams on the brakes when he sees a tree blocking the road. The car slows uniformly at the rate of $5.50m/s^2$ for $4s$, making straight skid marks $60m$ long ending at the tree.

Figure 4: Question 10



[Be careful with the sign. You will receive no points if you use the wrong sign in your calculation.] (a) What is the initial velocity of the car when the driver first slams on the break? (b) With what speed does the car then strike the tree?