

Physics 120

Exam #2

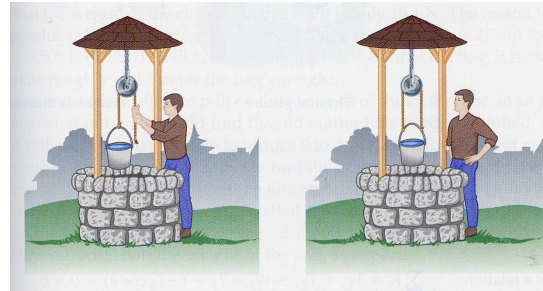
May 4, 2011

Name _____

Multiple Choice	/16
Problem #1	/28
Problem #2	/28
Problem #3	/28
Total	/100

Part I: Multiple-Choice: Circle the best answer to each question. Any other marks will not be given credit. Each multiple-choice question is worth 4 points for a total of 16 points.

1. A person hoists a bucket of water from a well and holds the rope, keeping the bucket at rest as in the left photo. Call this situation *A*. A short time later the person ties the rope to the bucket so that the rope holds the bucket in place as in the right photo. Call this situation *B*.



- The tension in situation *B* is greater than in situation *A*.
 - The tension in situation *B* is equal to that in situation *A*.
 - The tension in situation *B* is less than that in situation *A*.
 - There is no way that the individual tensions in the ropes can be determined.
2. A 2.0×10^3 kg car travels at a constant speed of 12 m/s around a circular curve of radius 30 meters. As the car goes around the curve, the time rate of change of the car's momentum is directed
- toward the center of the circular curve.
 - away from the circular curve.
 - tangent to the curve in the direction of motion.
 - tangent to the curve opposite the direction of motion.
3. If the Earth orbits the sun in a nearly circular orbit of radius $r = 1.5 \times 10^{11}$ m and the orbital period of the Earth in its orbit is $T = 31.5 \times 10^6$ s (1 year), the mass of the sun is most nearly given by the expression

a. $M_{Sun} = \frac{2\pi r^2}{GT^2}$ b. $M_{Sun} = \frac{4\pi^2 r^3}{GT^2}$ c. $M_{Sun} = \frac{2\pi^2 Gr^3}{T^2}$ d. $M_{Sun} = \frac{4\pi r^3}{GT^2}$

4. A spring of stiffness k is suspended from the ceiling and allowed to hang vertically. The spring has a relaxed length (measured from the ceiling) of L_o . A mass m is suspended from the spring and the spring stretches by an amount L (measured from the ceiling.) The stiffness of the spring can be approximated using

a. $k = \frac{m}{|L - L_o|}$ b. $k = \frac{|L - L_o|}{mg}$ c. $k = \frac{mG}{|L|}$ d. $k = \frac{mG}{|L - L_o|}$

Part II: Free Response Problems: *The three problems below are worth 84 points total and each subpart is worth 7 points each. Please show all work in order to receive partial credit. If your solutions are illegible or illogical no credit will be given. A number with no work shown (even if correct) will be given no credit. Please use the back of the page if necessary, but number the problem you are working on.*

1. Suppose that you are going to make a 1m long tungsten wire that has a square cross-sectional area of 1cm^2 . The density of tungsten is $\rho = 19250 \frac{\text{kg}}{\text{m}^3}$ and its molecular mass is $183.8 \frac{\text{g}}{\text{mole}}$.

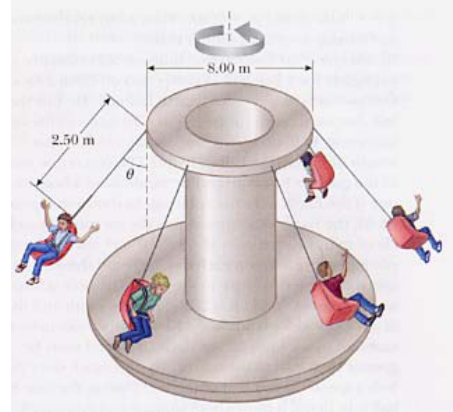
a. What is the interatomic bond spacing, d ?

b. What is the interatomic bond stiffness, k_{iab} ? (Hint: Assume that the wire has a stiffness $k_{\text{wire}} = 4.11 \times 10^7 \text{ N/m}$.)

c. What is Young's modulus for tungsten?

d. If a 5kg mass were hung from this wire when the wire is held vertical, by how much would the wire stretch?

2. An amusement park ride shown below, consists of a rotating circular platform 8.0m in diameter from which 10kg seats are suspended from a chain with mass 4kg and assume that the mass of the chain is located at the center of the chain. When the system rotates it does so at constant speed the chain makes an angle $\theta = 28^\circ$ with respect to the vertical and a 40kg child is riding in a chair.



- a. Starting with the momentum principle, what is the speed of the chair when it is empty (*no child is in the seat*)?
- b. What is the tension in the chain when there *is no child* in the chair?
- c. Again, using the momentum principle, what is the speed of the chair *when the child is in the seat*?
- d. What is the tension in the chain *when a child is in the chair*?

3. A block of mass $m = 5\text{kg}$ is moving along a horizontal frictionless surface at a constant velocity of $\vec{v}_i = \langle 2, 0, 0 \rangle \frac{\text{m}}{\text{s}}$. At a location taken as the origin the block encounters a region in which there is friction present and the coefficient of kinetic friction is $\mu_k = 0.08$.

a. Starting from the momentum principle $\frac{d\vec{p}}{dt} = \vec{F}_{net}$, what is the velocity of the block

as a function of time? (Hint: You will need the integral $\int_{x_i}^{x_f} x^n dx = \frac{x^{n+1}}{n+1} \Big|_{x_i}^{x_f}$.)

b. How long will it take before the block comes to rest? (Hint: Take time $t_i = 0$ when the block first encounters the region with friction.)

c. What is the final location of the block when it comes to rest?

d. Suppose that instead of friction bringing the block to rest, the block encounters a region of space (the beginning of which is taken again as the origin) over which the block is subject to a variable force given by $\vec{F}_{res} = \langle -\rho v^2, 0, 0 \rangle \text{N}$, where ρ is a constant with units of Ns^2/m^2 . In this case, what is the velocity of the block as a function of time, taking $t_i = 0$ when the block first encounters this variable force?

Useful formulas:

$$\vec{p} = \gamma m \vec{v} \quad k_{\text{eff, parallel}} = n_{\text{parallel}} k_{\text{individual}}$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \quad k_{\text{eff, series}} = \frac{k_{\text{individual}}}{n_{\text{series}}}$$

$$\vec{v}_{\text{avg}} = \frac{\vec{v}_i + \vec{v}_f}{2} \quad \text{stress} = Y \text{strain} \rightarrow \frac{F}{A} = Y \frac{\Delta L}{L}; \quad Y = \frac{k_{\text{tab}}}{d}$$

$$\vec{F}_g = m \vec{g}$$

$$\vec{F}_{\text{gravity}} = \frac{GM_1 M_2}{r_{12}^2} \hat{r}_{12}$$

$$\vec{F}_{\text{spring}} = -k \vec{s}; \quad \vec{s} = (L - L_o) \hat{s}$$

$$\rho = \frac{M}{V}$$

Momentum Principle: $\vec{p}_f = \vec{p}_i + \vec{F}_{\text{net}} \Delta t$

$$\frac{d\vec{p}}{dt} = \vec{F}_{\text{net}}$$

Position-update:

$$\vec{r}_f = \vec{r}_i + \vec{v}_{\text{avg}} \Delta t = \vec{r}_i + \frac{\vec{p}}{m \sqrt{1 + \frac{p^2}{m^2 c^2}}} \Delta t$$

Vectors

magnitude of a vector: $|\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$

writing a vector: $\vec{a} = \langle a_x, a_y, a_z \rangle = |\vec{a}| \hat{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k}$

Constants

$$g = 9.8 \frac{\text{m}}{\text{s}^2}$$

$$G = 6.67 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2}$$

$$1e = 1.6 \times 10^{-19} C$$

$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{C^2}{\text{Nm}^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{\text{Nm}^2}{C^2}$$

$$1eV = 1.6 \times 10^{-19} J$$

$$\mu_0 = 4\pi \times 10^{-7} \frac{\text{Tm}}{A}$$

$$c = 3 \times 10^8 \frac{\text{m}}{\text{s}}$$

$$h = 6.63 \times 10^{-34} Js$$

$$m_e = 9.11 \times 10^{-31} kg = \frac{0.511 MeV}{c^2}$$

$$m_p = 1.67 \times 10^{-27} kg = \frac{937.1 MeV}{c^2}$$

$$m_n = 1.69 \times 10^{-27} kg = \frac{948.3 MeV}{c^2}$$

$$1amu = 1.66 \times 10^{-27} kg = \frac{931.5 MeV}{c^2}$$

$$N_A = 6.02 \times 10^{23}$$

$$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

Geometry

Circles: $C = 2\pi r = \pi D \quad A = \pi r^2$

Triangles: $A = \frac{1}{2} bh$

Spheres: $A = 4\pi r^2 \quad V = \frac{4}{3} \pi r^3$