Final Exam (2018 Spring)

PHYS 205A-001: University Physics

Date: 2018 May 11

(Name) (Signature)

Instructions

1. Seating direction: Please be seated on seats with seat-numbers divisible by 3.
2. Total time = 120 minutes.
3. There are 10 questions in this exam.
4. Equation sheet is provided separately.
5. To be considered for partial credit you need to show your work in detail and organize it clearly.
6. A simple calculator (with trigonometric functions) is allowed.
7. Use of mobile phones is strictly prohibited. It should stay out of reach during the exam.

1. (**10 points.**) You come across the following expression

$$K = (r_1 + r_2)^2 \Big[h^2 + (r_2 - r_1)^2\Big]^{\frac{1}{2}}, \tag{1}$$

where the variable h represents distance. You do not know the definitions of the variables r_1, r_2, and K, a priori. Using dimensional analysis deduce if the expression K could represent a perimeter, a area, or a volume.

2. (**10 points.**) A fish is dropped by a pelican that is rising steadily at a speed $v_i = 3.0\,\mathrm{m/s}$. Determine the time taken for the fish to reach the water 10.0 m below. How high above the water is the pelican when the fish reaches the water?

3. (**10 points.**) If three vectors satisfy the relations

$$\vec{\mathbf{A}} - \vec{\mathbf{B}} = 2\vec{\mathbf{C}}, \tag{2}$$

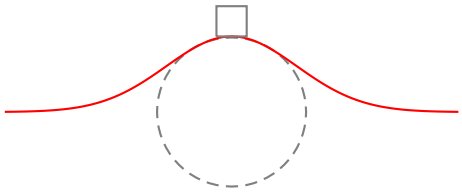
$$\vec{\mathbf{A}} + \vec{\mathbf{B}} = 4\vec{\mathbf{C}}, \tag{3}$$

where

$$\vec{\mathbf{C}} = 3\,\hat{\mathbf{i}} + 4\,\hat{\mathbf{j}}, \tag{4}$$

then what are $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$ in component form?

4. (**10 points.**) A stuntman drives a car over the top of a hill, the cross section of which can be approximated by a circle of radius $R = 150\,\mathrm{m}$. What is the greatest speed at which he can drive without the car leaving the road at the top of the hill?



5. (**10 points.**) Consider a block of mass $m = 25\,\text{kg}$ being pulled by a force $F_{\text{pull}} = 80.0\,\text{N}$, exerted horizontally, such that the mass moves on a horizontal surface with coefficient of kinetic friction $\mu_k = 0.30$. Assume that the mass starts from rest. Determine the work done by the force of friction acting on the block, while it has moved a horizontal distance $d = 10.0\,\text{m}$ starting from rest.

6. (**10 points.**) The potential energy of a particle moving along the x axis is given by

$$U(x) = ax^2 - bx^4, \qquad a > 0, \quad b > 0. \tag{5}$$

A characteristic plot of $U(x)$ with respect to x is shown in Figure 1. Determine the points on the x axis when the force on the particle is zero, that is, the particle is in equilibrium.

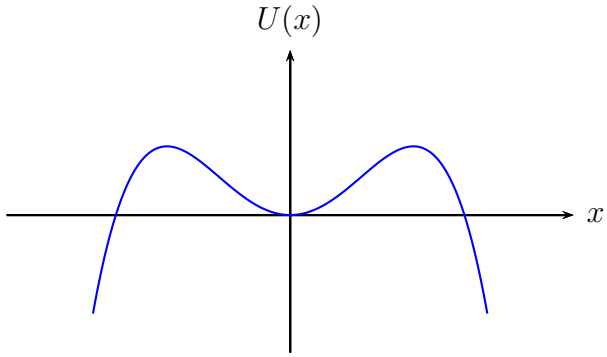


Figure 1: Problem 6

7. (**10 points.**) A bullet with mass $3.00\,\mathrm{g} = 3.00 \times 10^{-3}\,\mathrm{kg}$ is fired into a wooden block of mass $1.00\,\mathrm{kg}$, that hangs like a pendulum. The bullet is embedded in the block (complete inelastic collision). The block (with the bullet embedded in it) goes $30.0\,\mathrm{cm}$ high after collision. Calculate the speed of the bullet before it hit the block.

8. (**10 points.**) A uniform solid sylinder ($I = \frac{1}{2}MR^2$) of radius 10.0 cm and mass 1.00 kg is free to rotate about its symmetry axis. The cylinder acts like a pulley. A string wound around the cylinder is connected to a block of mass $m = 0.50$ kg, which falls under gravity. See Figure 2. What is the acceleration of the mass m?

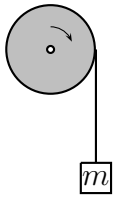


Figure 2: Problem 8.

9. (**10 points.**) A merry-go-round, in the shape of a disc, is free to rotate (without friction) about its symmetry axis. (It has mass $M = 100.0\,\text{kg}$, radius $R = 2.00\,\text{m}$, and moment of inertia $I = \frac{1}{2}MR^2$.) A kid (mass $m = 40.0\,\text{kg}$) walks from the outer edge of the disc to the center. If the angular speed of the merry-go-round was $\omega_i = 0.40\,\text{rev/s}$ when the kid was at the outer edge, what is the angular speed of the merry-go-round when the kid is at the center?

10. (**10 points.**) Neutron stars are extremely dense objects formed from the remnants of supernova explosions. Many rotate very rapidly. Suppose the mass of a certain spherical neutron star is half the mass of the Sun and its radius is 10.0 km. Determine the greatest possible angular speed it can have so that the matter at the surface of the star on its equator is just held in orbit by the gravitational force. Mass of Sun is 2.0×10^{30} kg.