Physics 231 — Mission 2: Kinematics & Inertial Frames & Newton's Laws (20+4pts)

Your solutions should be neat, correct and complete. Same instructions as Mission 1 apply here.

Recommended Homework from Textbook (Serway):
Chapter 4 $\#'s$ 9, 11, 13, 19, 23, 25, 26, 50 & Chapter 5 $\#'s$ 5, 7, 11, 12

Recommended Homework from Recommended Textbook (Young & Freedman, 9th ed):
Chapter 3 (two dimensional motion, projectiles, circlular motion, relative motion)
$\#'s$ 1, 4, 13, 15, 17, 19, 27, 29, 33, 37, 39, 43, 45, 49, 50, 51, 53, 55, 57, 59, 61, 63, 67, 71
Chapter 4 (Newton's Laws)
$\#'s$ 1, 5, 7, 9, 17, 21, 23, 27, 29, 31, 33, 37, 39, 43, 49, 51, 53

Suggested Reading the following resources may be helpful:

- **(a.)** Lectures 5, 6, 7 as posted on the course website,
- **(b.)** Chapters 2, 4, 5, 6 of the required text.

Problem 13: (2pts) Suppose $\vec{A} = \langle 1, 2, 2 \rangle$ and $\vec{B} = \langle -2, 0, 7 \rangle$. Find $\vec{C}, \vec{D}$ such that $\vec{B} = \vec{C} + \vec{D}$ where $\vec{C} \bullet \vec{D} = 0$ and $\vec{C}$ is colinear to $\vec{A}$.

Problem 14: (2pts) Suppose $\vec{c}$ is a constant vector. Further, suppose the initial position of a particle is $\vec{r}_o$ and the initial velocity is $\vec{v}_o$ at time $t = 0$. Given that the acceleration $\vec{a} = t\vec{c}$, find the velocity and position as a function of time t in terms of the given vectors.

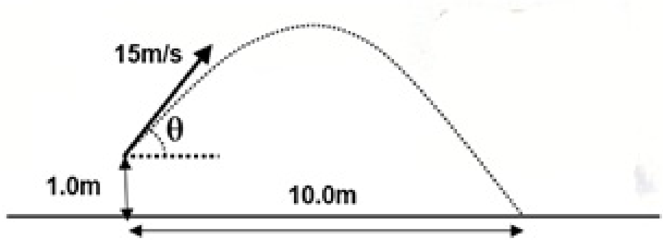
Problem 15: (2pts) A ninja wanders through a dense cloud of hidden mist. He takes 40 steps northeast, then 80 steps 60^o north of west, then 50 steps due south. Assuming he is facing due south at the end, tell him by what angle he should rotate **C**ounter-**C**lock-**W**ise(**CCW**) before walking straight to return to his initial starting point. Also, how many steps should will he need to return to the starting point? (answers of the form, he's a ninja so he can just jump, glide, etc... whatever, will be amusing, but will not earn points)

Problem 16: (2pts) A rocket car accelerates at $a = 3g$ over a distance of L. Then the car applies brakes which give $a = -g$ until the car comes to rest. Find the total distance the car travels. Your answer should be in terms of the given distance L.

Problem 17: (2pts) A projectile is fired in such a way that its horizontal range is equal to three times its maximum height. At what angle of inclination was the projectile fired. Assume a level landscape and ignore air friction.

Problem 18: (2pts) Imagine you shoot an arrow at a speed of v_o at an angle of inclination of $\theta = 30^o$. If the arrow leaves the bow at a height of $2.0\,m$ above the ground and you are trying to shoot a cat (it's evil, in case you're worried) in a tree $200\,m$ away in a branch $22\,m$ above the ground. Find the speed v_o needed in order to shoot the cat.

Problem 19: (2pts) Ron Swanson mistakedly orders a *sausage* sandwhich at a vegan run donut shop. After taking a bite he recoils in horror and throws the faux-meat entree at 15 m/s as shown below. At what θ did Ron Swanson throw the pathetic veggy sandwhich?



Problem 20: (2pts) Consider coordinate systems (x_1, x_2, x_3) and (y_1, y_2, y_3) and (z_1, z_2, z_3). Suppose a given particle has the following trajectories as measured by the x, y and z observers respective:

$$\begin{aligned}(x_1, x_2, x_3) &= (1 - t,\ 2 + 2t,\ 3 - 7t + t^2)\\ (y_1, y_2, y_3) &= (3t,\ 4,\ 8t + (t-1)^2)\\ (z_1, z_2, z_3) &= (4 - t,\ 4t,\ t^3)\end{aligned}$$

(a.) Calculate velocities with respect to the given coordinate systems: $\vec{v}_X, \vec{v}_Y, \vec{v}_Z$.

(b.) Calculate accelerations with respect to the given coordinate systems: $\vec{a}_X, \vec{a}_Y, \vec{a}_Z$.

(c.) Suppose that (x_1, x_2, x_3) is an inertial coordinate system. Which of the other coordinate systems *could* be inertial as well ?

Problem 21: (2pts) Suppose two observers (x_1, x_2) and (y_1, y_2) are related at time t according to

$$(y_1, y_2) = (t + \cos t + x_1, t + \sin t + x_2)$$

(a.) Show that the observes are not inertially related.

(b.) Suppose $(x_1, x_2) = (1 - t, 2 - t)$. Find the trajectory in (y_1, y_2) and describe the geometry of the trajectory. Is this object in *uniform rectilinear motion* ? Why is this a tricky question ?

(c.) Suppose (x_1, x_2) is an inertial coordinate system in which the net-force on a particle with mass m is measured to be zero. Find the acceleration of that particle in the non-inertial frame (y_1, y_2).

Problem 22: (2pts) Let $\widehat{u}$ be a unit-vector directed 30^o north of west. Suppose forces

$$\vec{F}_1 = (3.0\,N)\hat{\mathbf{x}} + (6.0\,N)\hat{\mathbf{y}} \qquad \& \qquad \vec{F}_2 = (20\,N)\widehat{u}$$

act on a body with mass $M = 10\,kg$. Find the magnitude and direction of the resulting acceleration of the mass.

Problem 23: (2pts) Consider a box with mass $m = 20\,kg$ which rests on a floor with coefficient of static friction $\mu_s = 0.7$ and coefficient of kinetic friction $\mu_k = 0.5$.

(a.) If F_o is applied horizontally to the box, then what is the maximum force which can be applied without the box moving ?

(b.) Supposing the box is given a nudge to start the box sliding, then what is the acceleration of the box if it continues to be pushed with force F_o horizontally after it begins moving ?

Problem 24: (2pts) A car travels on a flat circular track of radius $R = 50\,m$ with wheels that have a coefficient of friction of $\mu = 0.9$.

(a.) What is the maximum speed v possible for the car to stay on the track ?

(b.) At a particular time, the car is increasing its speed according to $dv/dt = 2m/s^2$. What is the maximum speed v the car have under such an acceleration if it is to stay on the track ?