MIDTERM I PROBLEM PRACTICE SET

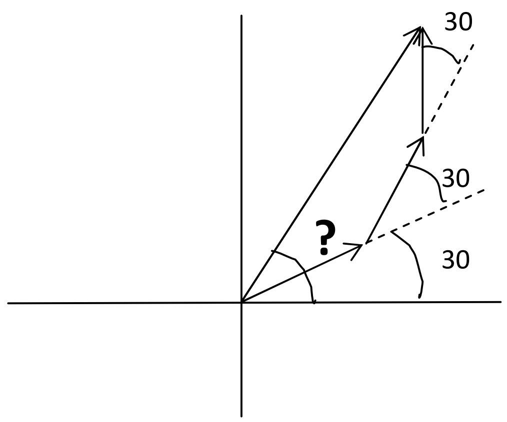
This is the problem practice set for PHY101 MIDTERM I; this problem set essentially covers all the topics and the types of the problems that can be given on your midterm exam. (This doesn't mean that the problems will be the same, but if you know and understand how to solve all of these problems, then you should be able to answer all of the practical questions on the exam.) This is also your compulsory homework to be submitted in two weeks (to your next regular physics class). I will be also preparing and uploading to this website a Turkish-English translation table for the physics terms that you should know. If this file is not here right now, please check again a little later.

The midterm exam will consist of 5 to 10 questions containing both practical problems, such as below, and theoretical questions like "Define uniform accelerated motion", "What are the equations of motion for uniform motion", "What are the three relativity laws", or "What is the moment of motion", etc. Any topic previously given in the class can appear on a theoretical question. Since the material given in the class did not strictly correspond to your textbook, I strongly advise you to use class notes in your preparation for the exam.

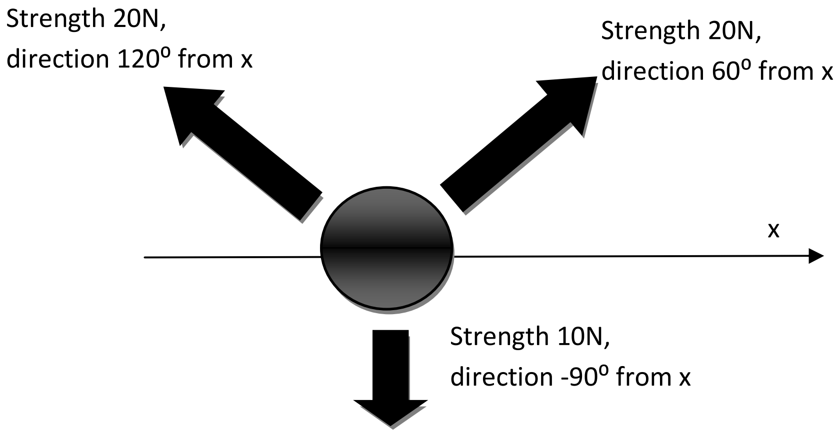
According to the exam rules, you can bring with you and use two two-sided A4 papers of any hand-written notes. No notebooks, books, or photocopies of any kind will be allowed. You also will not be able to use any electronic device other than calculator. You can bring a calculator with you, although the questions in the exam will be designed in such a way that you will not need the calculator to answer them. You will not be able to use the calculator in your cell phone. I also strongly advise you to bring a separate dictionary to the exam; you will be allowed to use dictionaries.

PRACTICE PROBLEMS

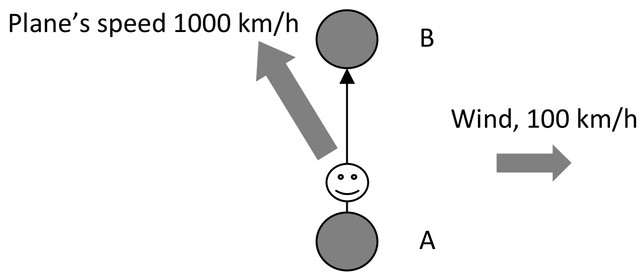
1. A dog looking for food moves first 10 meters away in the direction of 30 degrees counter-clockwise from the "+x" direction. Then, it turns 30 degrees to its left and continues to move 10 meters more. Then again it turns 30 degrees to the left and moves 10 meters more. What is the angle between the "x" axis and the final position of the dog (see figure below; to solve this problem you have to forget about geometry you learned in school and use vector calculus as I taught you in the class).



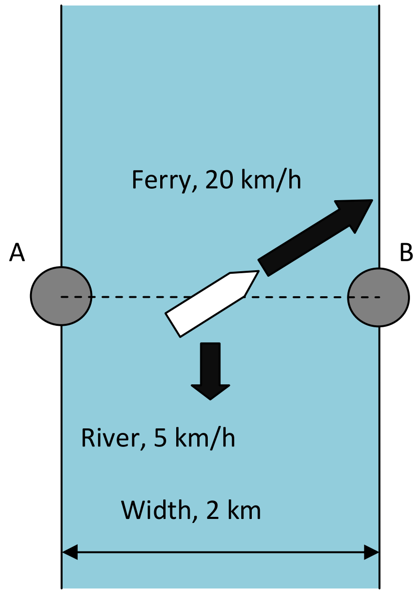
2. An object of mass m=10 kg is acted upon by three forces as shown in the figure below. What is the direction and the acceleration of the resulting object's motion?



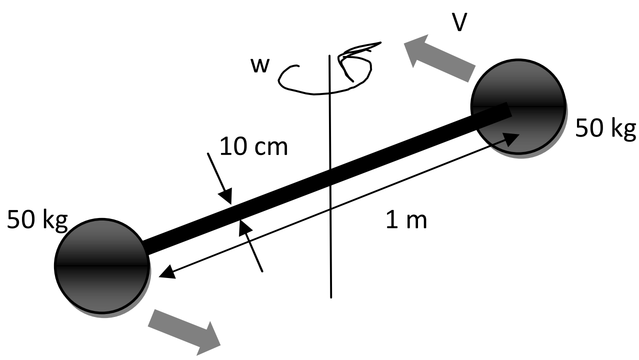
3. An object moves according to the law $X(t)=(t-t^2,t^3)$ (vector) , where time *t* is in seconds and position *X* is in meters. Calculate:
    a. Instantaneous speed of the object as a function of time, V(t) (vector).
    b. Instantaneous acceleration of the object as a function of time a(t) (vector).
    c. The magnitude and direction of the object's speed at time t=1 sec.
    d. The displacement vector from time t=1 sec to t=2 sec.
    e. The angle between the displacement vector in (d) and speed in (c).
4. Prove that if the position of an object of mass *m* at time *t* is described with the formula $X(t)=A\cos(wt+B)$, where A, B and w are some constants (such motion is called harmonic or oscillatory), then the force acting on the body has to comply with the following law: $F=-mw^2X$.
5. These two problems are essentially the same:
    a. A airplane flies from point A to point B in a straight line, as shown in the figure below. The airplane's air speed (that is speed *relative* to air) is 1000 km/h, and there is a wind of speed v=100km/h blowing in the direction as shown in the figure. In what direction should the pilot direct the airplane in order to fly straight towards point A? What will be the ground speed (that is relative to the ground) of the airplane then?



    b. A ferry (a type of ship) needs to cross a river from ferry-station A to ferry-station B in a straight line. The boat's engines can develop speed of 20 km/h (this means – relative to water) and the river flows with speed 5km/h, as shown in the figure below. In what direction should the boat move in order to approach station B from station A in a straight line? How long will it take to reach station B if the width of the river is 2 km?

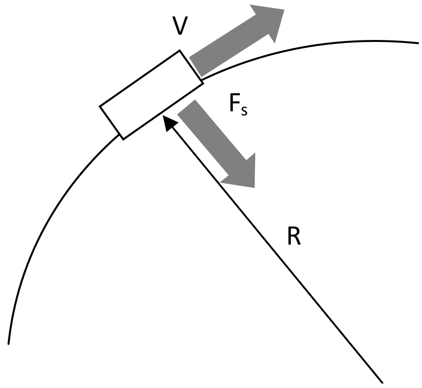


6. Flywheel is a device for storing energy using rotational motion. One design of a flywheel is shown below; it consists of a steel rod of length 1 m and round cross-section of diameter 10 cm, and two heavy balls of mass 50 kg each at the ends of the rod. The flywheel can be rapidly rotated around the central axis in order to store energy. The amount of energy stored is proportional to the square of the speed of the rotation w^2; that is if the flywheel rotates twice as fast it can store four times more energy. If the flywheel rotates too fast, however, it will break apart. Assuming that you know that the ultimate strengths of the steel making up the rod is $5{\cdot}10^8$ N/m^2, at what rotational speed w will the flywheel break up? Assuming you know that the yield strength of the steel making up the road is $2.5{\cdot}10^8$ N/m^2, what is the largest angular speed of the flywheel at which it can be operated without causing irreversible damage to the flywheel? (You can solve this problem by thinking in terms of a non-inertial observer sitting on one of the balls and turning together with the flywheel.)



7. A fox chasing a rabbit moves according to the law $X=(t,2t^2)$, where t is in seconds and X is in meters. The rabbit's position is described by the law $X=(-t^2,t/2)$. Prove that the rabbit and the fox move at all times with velocities <u>perpendicular</u> to each other.

8. When building a highway, the engineers should calculate all the turns so that the cars can move through them at high speeds and without crashing. When a car is turning, the force that allows it to turn is the friction force (in fact –static friction). In a really bad weather the coefficient of [static] friction between the road and the car wheels can be as low as k=0.1. If the cars are expected to move through the turn at a speed of 100 km/h, and assuming that the turn is made as a segment of a circle, what minimal radius of that circle (in meters) should the engineers choose?



9. A goalkeeper in a football game kicks the ball so that after *t*=2 second the ball is at a position x=20m and y=14 m (assuming the position of the goalkeeper is (x,y)=(0,0) m). Answer all of the following:
    a. What was the ball's initial speed?
    b. How long will the ball be in the air?
    c. How far will the ball travel before hitting the ground?
    d. What will be the maximal height of the ball?
    e. When will the ball reach the maximal height?
10. A tank fires its gun at the angle of 30 degrees to the horizontal. Assuming that the target is at the same level with the tank and the projectile hits the target 15 seconds later, how far is the target?