Physics 203 May 27, 2015
Tutorial Session #1 Vectors

These are the notes for the tutorial session #1. The topics including vectors, units, dimensional analysis, and trigonometry. Some of the problems which are a bit more advanced will be marked with an asterisk (*). It means that solving them might not help you on the quiz or the exams, but it's fun to think about these problems.
Keywords: Vectors, Dimensional Analysis, Units, Trigonometry

1) Which one of these formulas can be right? Remember that $[v] = [L][T]^{-1}, [a] = [L][T]^{-2}, [x] = [y] = [L], [t] = [T]$.
a) $x = vt^2$,
b) $x + yt = M/t$,
c) $x/t^2 = F/m$.

2) 1.11 from the textbook (9th edition of Physics by Cutnell and Johnson)
The period of oscillations for a mass-spring system is given by the formula $T = 2\pi\sqrt{m/k}$. Find the dimension for k. What is k's unit if T is in s and m is in kg? [Answer: $[k] = [M][T]^{-2}$, unit of k: kg/s^2.]

3) Find the period of a pendulum in terms of mass, length, and gravity g. In other words, assume you know there is a power low $T = C\ l^{\alpha}M^{\beta}g^{\gamma}$, and find α, β, and γ, only using the dimensional analysis. C is a dimensionless constant. [Answer: $\alpha = -\gamma = 1/2, \beta = 0$.]

4) 1.60 from the textbook (9th edition of Physics by Cutnell and Johnson)
Consider a pipe with length L and radius R. The pressure difference between the two ends of this pipe is ΔP. From physics we know that the volume flow rate Q depends on the viscosity of the fluid, η, which has the dimension $[M]/([L][T])$, like $Q \propto 1/\eta$. Explain why $Q \propto 1/L$. Write a formula for Q in terms of R, L, ΔP, and η, using dimensional analysis. [Answer: $Q = CR^4\Delta P/(\eta L)$.]

5) 1.69 from the textbook (9th edition of Physics by Cutnell and Johnson)
You are using a compass while scuba diving. The water is still. You know you went $\mathbf{A} = 100$ ft, 60° south of west, $\mathbf{B} = 200$ ft, 35° south of east, and $\mathbf{C} = 150$ ft, 23° north of east. How can you get back, in a straight line, to the point you have started the dive? [Answer: $\mathbf{D} = 290$ ft, 30° north of west.]

6) 1.68 from textbook (9th edition of Physics by Cutnell and Johnson)
You wanna know the ratio of the height of your neighbor's house to your house. You climb to the top of your building and measure the angle between the line of sight and horizontal line to be 21° for the top of the other building and -52° for the base of the other building. Find the ratio between heights of these two buildings. [Answer: 1.3.]

7) *
a) Prove that the diagonals of a parallelogram bisect each other.
b) Prove that the midpoints of any quadrilateral sitting in three dimensional space would form a parallelogram.

8) 1.20 from the textbook (9th edition of Physics by Cutnell and Johnson)
Consider yourself standing on the shore, with the height of almost 2 m. A boat's height on water is 10 m. How far the boat must be from the shore so that you cannot see the boat anymore, even using a good telescope? [Answer: 16 km.]

9) 1.19 from the textbook (9th edition of Physics by Cutnell and Johnson)
In a cube, find the angle between the diagonal passing through the center and the diagonal of one side. [Answer: $\tan^{-1}(1/\sqrt{2})$.]

10) 1.48 from the textbook (9th edition of Physics by Cutnell and Johnson)
Find the ratio F/F_A. The net force $\mathbf{F}$ containing F_A and two other forces at 20° with $\mathbf{F}_A$, with all having the same magnitude F_A. [Answer: 2.88.]

11)
You want to pass a river which flows at 5 km/h. The width of the river is 20m.
a) You can row at 8 km/h. Find the angle of the boat so that you end up at the point right in front of you on the other side, Q. [Answer: 39°.]
b) You can row at 2 km/h. Is it possible to end up at Q.
c) You can row at 4 km/h. Find the angle of the boat so you get to the other side at minimum time. Calculate this time. [Answer: The angle is zero.]
d) * You can row at 4 km/h. Find the angle of the boat so you end up at a minimum distance from the Q.