Homework 25

This is a review homework. Some of the problems may appear on the physics battle next Sunday.

Problem 1 (Aircraft carrier)

A fighter jet taking off from an aircraft carrier ship accelerates at 15 m/s^2 for 8 seconds.

a) What is the takeoff speed of the jet?
b) At least how long should the flight deck of the aircraft carrier be?

Problem 2 (Elevator safety)

An elevator with people inside is going up with acceleration 3 m/s^2. The mass of the elevator cabin is 600 kg. The cable supporting the elevator withstands force up to 13000 N, after which it might break. What is the maximal number of people that can be allowed into the elevator at the same time? An average person weighs 80 kilograms.

Problem 3 (Meteorite)

To model a meteorite, assume that someone drops a big rock of mass 1000 kg from the height of 5000 km above the Earth. Take initial temperature of the rock to be – 100 ℃.

a) What speed will the rock reach by the time it hits the Earth's surface, assuming mechanical energy conservation?

b) At such high speeds air resistance in the atmosphere becomes huge, so a lot of kinetic energy is converted into heat. If 2% of mechanical energy is converted into heat, find the final temperature of the rock. Take specific heat of the rock to be 800 J/(kg· ℃)

Note: in reality, Earth's gravity strength is very significantly altered at 5000 km above the surface, so the usual potential energy formula is not applicable and there is another, more general one. However, in this problem I suggest that we stick to the simplest model and use our usual potential energy formula. I also suggest to assume that all the heat is released in the rock uniformly across its volume – while in reality the outer layers get significantly hotter.

Problem 4 (Flying elephant)

If you had an unlimited supply of helium balloons, how many balloons would be needed to lift an African elephant? Mass of the elephant is 5000 kg. Each balloon has volume 10 liters. The density of atmospheric air is 1.3 $\mathrm{kg/m^3}$.

How would the answer change if you also account for the mass of each balloon and helium inside it, 8 grams?

Pictures – no need to print