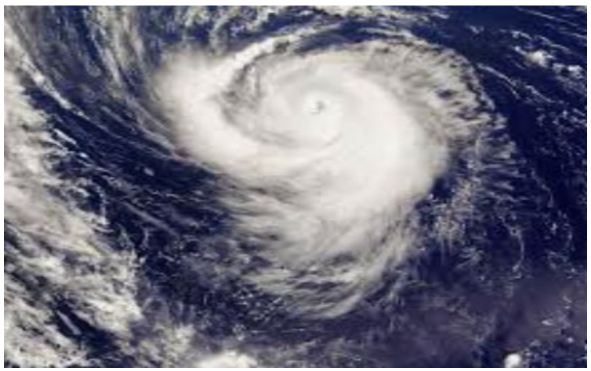
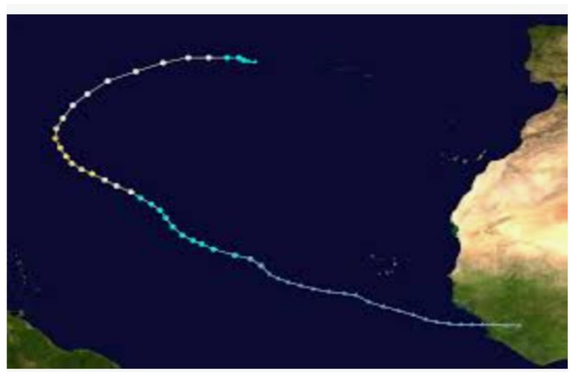
Drone and hurrican Eduard

In 2014 hurricane Eduard attacked Bermudes





The National Oceanic and Atmospheric Administration (NOAA) dispatched several drone-aircrafts that were able to track it and measure its wind characteristics at any distance, including “eye” of the hurricane!

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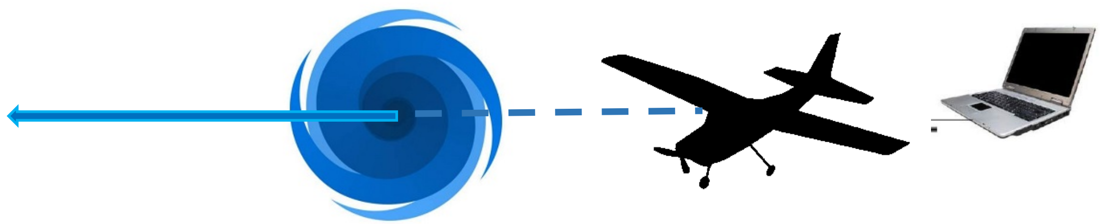
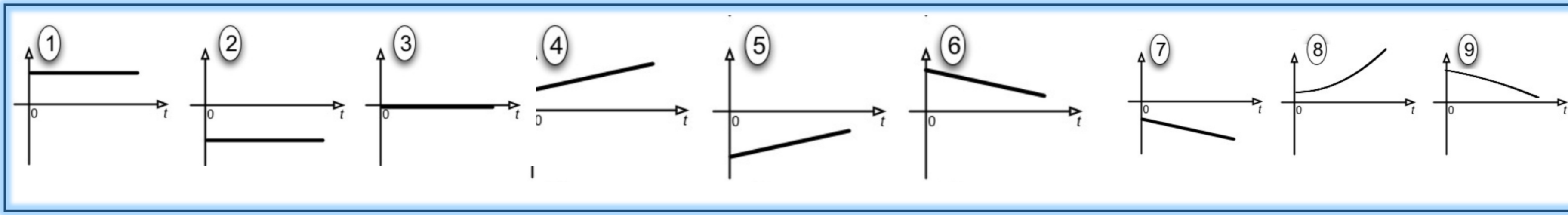
Consider short-time situation when Eduard starts at the drone position and is moving towards left, speeding up at a uniform rate.



Episodical examples of behaviour wind position/speed/acceleration are shown below.



- Which graphs can correctly describe what would be shown on the screen if we chose to plot: (i) position, (ii) speed, (iii) acceleration.
- Could the graphs you chose be consistent (all describe the measurement)?

What we have to do here is make the connection between our physical picture of the motion and a representation of that motion in the graph. What ranger of drone typically reports is the distance an object is away from it- a positive number. That means in this case to the left is positive. Since it reports the distance the object is away from it, 0 must correspond to the hurricane eye being right at the drone. We then have to decide how the graphs are representing the measurements. Although the graphs are asked for in a particular order, we don't have to do them in that order. It says the hurricane is "speeding up at a uniform rate." Since it tells us about speed, let's start by figuring out the velocity graph. First, "speeding up" - means that the velocity is not constant but its magnitude is growing. This rules out graphs 1, 2, and 3, which are each constant. Next, let's consider whether the value of the velocity is positive or negative. It says "speeding up" but that doesn't say anything about the direction and the sign of the velocity tells the direction. Since we've decided from the way the drone ranger works that to the left is the positive direction and since it says it's moving to the left, the velocity should be positive and remain so, because if it's speeding up it won't turn around. This rules out graphs 5 and 7. Then, we note that it says it is "speeding up" so it should go from positive to even more positive. This rules out graphs 6 and 9. We are left with 4 and 8. Finally, it tells us that it is not just speeding up, but "speeding up at a constant rate". That means the rate of change of the velocity (derivative) is a constant. If the rate of change of a function is a constant, then the function is a straight line. This leaves us with graph 4. (Since it's going in the positive direction it should be going up and at a constant slope)

Now that we have the velocity, we can easily get the acceleration since a = dv/dt. This tells us that the acceleration is just the slope of the velocity graph. Since the slope of the velocity graph doesn't change, the acceleration will be constant. This means it has to be either graph 1, 2, or 3. Since the velocity is increasing (getting more positive) the change in the velocity is positive and the acceleration will be positive. This means graph 1.

Lastly, we have to figure out the position graph. Our mental picture tells us that it is starting at a positive value and moving to a larger and larger positive value. Only graphs 4 and 8 do that. Could it be either? If it were increasing its distance from the origin at a constant rate as in graph 4, the rate of change of the position (v = dx/dt) would be a constant, but we know that it is speeding up. So graph 4 doesn't work. Does graph 8? We can read off its velocities by looking at the slopes. Since in graph 8 the graph curves up, the slopes get larger and larger with time so graph 8 is describing a car that is speeding up. (We can use a little math here. We know that if the velocity is increasing at a constant rate it is described by an equation that looks linear in time: something like $v = v_0 + at$. The function x has to have its derivative look like this. What function of t has $df/dt = t$? You should recognize that the answer is $\frac{1}{2}t^2$. So the position graph should look like a parabola. Note that we would have had to reject graph 8 if it started at 0 by the way the drone ranger works!

So our answers seem to be: the position: 8; the velocity: 4; the acceleration: 1

We are almost guaranteed to have consistency among our three graphs but not quite. We constructed them by checking the slopes from each other. But we also have to check that the values are consistent. Even though we noticed that the position graph starts at a positive value (and not at 0), we also have to check that the initial values match. We can read the initial velocity off the velocity graph! Looking at this closely, it looks as if the curve for the position graph comes in flat - that is, at 0 slope. This means that for graph 8, it is describing the motion of a car that is moving to the left and speeding up, but it is describing one that starts at t=0 with 0 velocity. Graph 4 does not start with 0 velocity so those two graphs are not consistent. The graphs belong to different motion (measurement).