**Unit A Project – Kinematics**

**Part A:**

The **cheetah** is an atypical member of the cat family that is unique in its speed and stealth while lacking climbing abilities. It is the fastest land animal, reaching speeds between 112 kilometers per hour and 120 kilometers per hour in short bursts covering distances up to 460 meters and has the ability to accelerate from 0 to 110 kilometers per hour in three seconds, greater than most [supercars](http://en.wikipedia.org/wiki/Supercars). The cheetah is a [carnivore](http://en.wikipedia.org/wiki/Carnivore), eating mostly [mammals](http://en.wikipedia.org/wiki/Mammal) under 40 kilograms (88 lb), including the [Thomson's gazelle](http://en.wikipedia.org/wiki/Thomson%27s_gazelle), the [Grant's gazelle](http://en.wikipedia.org/wiki/Grant%27s_Gazelle), the [springbok](http://en.wikipedia.org/wiki/Springbok_%28antelope%29) and the [impala](http://en.wikipedia.org/wiki/Impala). The cheetah hunts by [vision](http://en.wikipedia.org/wiki/Visual_perception) rather than by [scent](http://en.wikipedia.org/wiki/Scent). Prey is stalked to within 10 meters - 30 meters and then chased. This is usually over in less than a minute, and if the cheetah fails to make a catch quickly, it will give up. The cheetah has an average hunting success rate of around 50% - half of its chases result in failure. Gazelles are known as swift animals; they are able to reach high speeds (as high as 80 kph) for long periods of time.

A cheetah is stalking a gazelle in the Serengeti Grasslands. The cheetah has approached the gazelle to within a distance of 70 m.

1. What distance can a gazelle cover in 1 min assuming uniform motion at its top speed?
2. How much distance does the cheetah need to reach its top speed of 120 km/h?
3. What will be the distance between the cheetah and the gazelle as soon as the cheetah has reached its top speed?
4. Starting a t = 3.0 s (when both the cheetah and gazelle will be traveling with uniform motion), use a graph (with labeled axes and a title) to prove whether the cheetah will be able to catch the gazelle in less than a minute.

**Part B:**



The next day, the cheetah attempts to catch gazelle again. This time cheetah begins by stalking gazelle while gazelle isn’t aware. The gazelle starts at the local watering hole. It travels 65 m east, then 32 m [38˚ S of E], and finally 46 m [71˚ E of N] until it reaches the Grumeti River. It then proceeds to swim at a speed of 2.8 m/s directly east across the river which is flowing south at a speed of 6.0 m/s. The cheetah stalks the gazelle by walking in a straight-line path from the local watering hole to the same point on the bank of the Grumeti River where the gazelle crossed. At this point, the Grumeti River is 250 m wide. The cheetah points himself in such a way that when he swims across the river, he will reach the opposite shore directly across from where he started. At this time, the gazelle spots the cheetah and the chase begins…

1. Find the distance and direction the cheetah must travel from the watering hole in order to reach the same point at which the gazelle entered the water.
2. Find the velocity of the gazelle relative to the shore as it crosses the river.
3. Find the time it will take for the gazelle to cross the river.
4. How far downstream will the gazelle land when it reaches the opposite shore?
5. In what heading should the cheetah travel in order to land directly across from where he started?

**Part C:**



The chase continues until they reach a 2.0 m-high grassy knoll. When the gazelle is at the edge of the knoll, and the cheetah is 10 m behind, it leaps into the air with a velocity of 80 km/h at an angle of 32˚ to the horizontal. It lands a certain distance from the base of the knoll and continues running. The cheetah runs horizontally off the knoll and lands in the same spot the gazelle landed.

1. Find the peak height of the gazelle relative to the bottom of the knoll.
2. Find the vertical velocity with which the gazelle will land.
3. Find how far from the base of the knoll the gazelle will land.
4. How long will the cheetah be in the air as it runs horizontally off the knoll?
5. How fast would the cheetah be traveling off the knoll (assuming uniform motion) in order to land in the same spot as the gazelle did?
6. Describe two ways in which the cheetah could catch the gazelle in mid-air.
7. Describe a way in which the cheetah, traveling faster, than the gazelle would not catch the gazelle in mid-air.