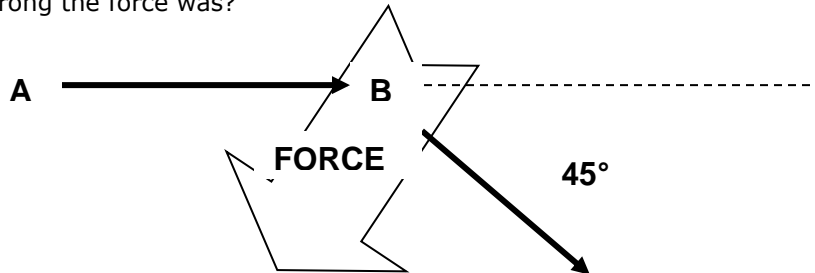


UNL2207 - The Nature of Natural Law: Tutorial 4

Centripetal motion, projectiles & Newton's Law of universal gravity

1) An object with a known mass, one kilogram say, is moving from A to B at a known speed, say one meter per second. At B a force acts on the object. The force does not change the object's speed, but does change its direction of motion by 45° . Is it possible to calculate how strong the force was?

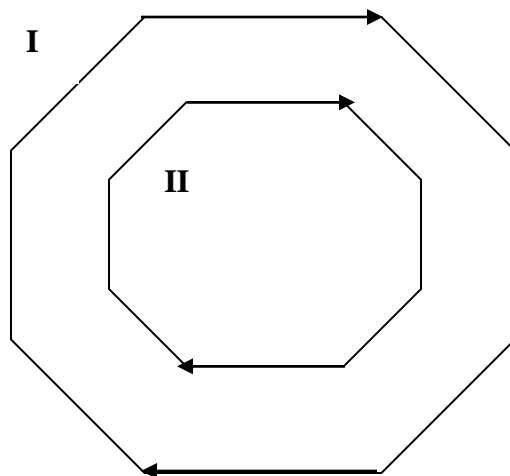


- a) Yes, it can b) No, it cannot be calculated (by anyone)

2) Suppose that two identical objects go around circles of identical radii, but one object goes around the circle twice as fast as the other. The turning (*i.e.* centripetal) force required to keep the faster object on its circular path is:

- a) the same as required to keep the slower object on its path b) one-fourth as much
c) half as much d) twice as much e) four times as much

3) An object goes around the bent path I with a speed of 1 km/h. An identical object goes around the bent path II with the same speed. The (average) radius of bent path II is half that of the path I. The average force required to keep the object moving along path II is:



- a) The same as the average force on the object in path I b) Half this force
c) Double this force d) Four times this force e) A quarter of this force.

4) What will happen if two identical cannons are aimed at each other and the shells fired simultaneously and at the same speeds? One cannon is higher than the other, but the two are perfectly aligned.

5) If the earth had no atmosphere (or mountains to interfere) could a satellite, given adequate initial velocity, orbit arbitrarily close to the earth's surface – provide it did not touch?

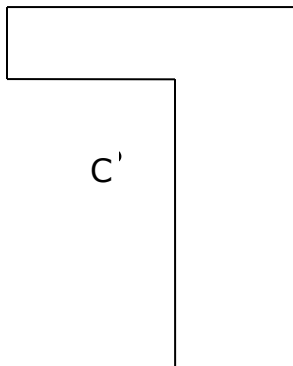
- a) Yes, it could b) No, orbits are only possible at a sufficient distance above the earth's surface where gravitation is weaker

If your answer is yes; are you able to find what this velocity should be?

Repeat your calculation, but now for the Moon instead, regarding it as the orbiting satellite, at its present average distance from the earth of 384,000 km, and with a period of 27.3 days.

6) Is it possible to get beyond the earth's gravitational pull (or field) if you go far enough away from the earth?

7) Newton's law of universal gravity says that the gravitational force between two objects is proportional to the product of their masses and inversely proportional to the square of the distance between their centres of gravity. Is this a correct statement of the law? Before answering, consider the object below:



where C is its centre of mass. A small sphere placed at precisely the point C should experience therefore an infinite attraction which is clearly absurd. Even more bizarre would be placing the small sphere at a point nearer to the object than C, in which case its movement would look as if it were being repelled!

8) A meter ruler will balance on your finger if you support it at its mid-point or centre of gravity because its two halves have equal weights. Similarly, a broom will also balance if you support it at its centre of gravity. Suppose you cut the broom at its centre of gravity into two pieces and weighed each. Would they have equal weights?

- 9) Determine the mass:
- of the earth (assumed spherical, and of a uniform density), given that it's radius is 6,380km.
 - of the Sun given that the Earth's distance from the Sun is 1.5×10^{11} meters.
- 10) Say you performed an experiment to measure the acceleration due to gravity in a cave deep below the surface of the earth, would the *likely* (unless you actually perform an experiment, you cannot be entirely confident of the result!) outcome be greater or less than at the surface – i.e. would an object weigh more or less in the cave than at the surface of the earth?
- 11) The first experimental evidence that the Earth cannot be exactly spherical (it's actually an oblate spheroid) came from pendulum observations. A simple pendulum adjusted so that it swings seconds at Paris, say, must be shortened before it swings seconds at the equator. Explain this effect; if a pendulum has a period of 1s at the equator, but its period at the north-pole is observed to be only 0.997s, what is the difference between the equatorial diameter and the N-S diameter of the earth.
- 12) Show that the *acceleration due to gravity* (g) of a falling object of mass m , near the earth's surface is indeed independent of m and calculate its approximate value. Obtain an expression for the fractional change in g with increasing altitude, and estimate the rate at which it changes.
- Can you think of any other effects that would cause g to vary?
- 13) Which of the following is correct?
- the moon goes around the centre of the earth
 - the earth goes around the centre of the moon
 - they both go around some point in between their respective centres