EXERCISE 8.A

Projectile motion

1. A projectile is thrown horizontally with a speed of 300m/s from the top of a building 78.4m high.
a) Compute the range of the projectile.
b) What is the time taken to reach the ground?
2. A machine gun throws a projectile with a speed of 740m/s Find the range, the maximum height reached by the projectile and the time taken to reach the ground,
when it is projected through an angle of 45°.
3. The range of the motion of a projectile is $20\sqrt{3}$ m when it is projected from the ground with a speed of 20m/s What is the maximum height reached? $g = 10\text{m/s}^2$.
4. A projectile thrown through an angle of 30° reaches 50m. Find the initial speed.
5. A football player punts the ball so that it will have a "hang time" (time of flight) of 4.5s and land 45.7m away. If the ball leaves the player's foot 1.52m above the ground, what is its initial velocity
(magnitude and direction)?
6. A projectile is fired with an initial speed of 400m/s at an angle of 60° above the horizontal from the top of a cliff 49m high. Determine the:
a) time to reach the maximum height.
b) maximum height above the base of the cliff reached by the projectile.
c) total time it is in the air.
d) horizontal range of the projectile.
7. A projectile is fired with a speed of 600m/s at an angle of 60°. Find:
a) the horizontal range.
b) the maximum height.
c) the speed and the height after 30s.
d) the time and the speed when the projectile reaches 10km.
e) the time to reach the maximum height.
8. From the top A of a cliff 100m high, a projectile is fired at angle 45°. The initial speed is 400m/s and $g = 10\text{m/s}^2$. Determine:
a) The maximum height.
b) The horizontal distance below A and the point where it strikes the ground.
c) The time taken to travel the total distance.
d) The velocity when it strikes the ground.
9. A rescue plane is flying at a constant elevation of 1200m with a speed of 430km/h toward a point directly over a person struggling in the water. At what angle of sight θ should the pilot release a rescue capsule if it is to strike (very close to) the person in the water?
10. A police officer is chasing a burglar across a roof top; both are running at 4.5m/s Before the burglar reaches the edge of the roof, he has to decide whether or not to try jumping of the next building, which is 6.2m away but 4.8m lower. Can he make it? Assume that he jumps horizontally.

Extension questions

1. A bomber (plane) is at an altitude of 20km and has 400km/s of speed. When the plane is above a certain point, it releases a bomb. How long will it take the bomb and at what distance from the same
point to reach the ground?
2. A gun fires a projectile of mass 2kg at initial velocity $V_0 = 200\text{m/s}$ making an angle $\theta_o = 53°$ with the ground.
a) Find; (i) The kinetic energy of the projectile at the point where it leaves the gun.

(ii) The potential energy at the highest point of the flight; deduce the velocity of the projectile at that point.

(iii) The range of the projectile; what is the time taken for the flight?

b) Find the position of the projectile, the magnitude and direction of the velocity when t = 25.

3. A ball is thrown horizontally with a speed V_0 of 243.8cm/s. Find the position and velocity after 25.

4. A ball is thrown vertically upward in air and returns in the hand from which it was 3s later. A second ball is thrown at an angle of 30o with the horizontal. At which velocity must the second ball be thrown so that it reaches the same maximum height as the first one thrown vertically?

5. a) A projectile is launched with speed V_0 at angle $\propto_0$ above the horizontal. The launch point is at a height h above the ground. Show that if air resistance is ignored, the horizontal distance that the projectile travels before striking the ground is= $\frac{v_0 \cos\alpha_0}{g}\left(v_0 \sin\alpha_0 + \sqrt{v_0^2 \sin^2\alpha_0 + 2gh}\right)$

b) Determine x if h is taken to be zero.

Circular motion

1. A body describes a circumference of radius 2m and the motion is uniform. It does 2 rotations in 6s. If π^2 = 9.86, find the centripetal acceleration.

2. A moving body is in uniform circular motion. The radius of the circle is 25m. Assuming that the acceleration equals 9m/s^2, find the angular velocity.

3. How many rotations a wheel of 3.20m diameter does in one minute. Assuming that the linear speed is equal to 16m/s?

4. A ball at the end of a string is swinging in a horizontal circle of radius 1.15m. The ball makes exactly 2.00 revolutions in a second. What is its centripetal acceleration?

5. The wheel of an engine of 4m diameter does 90 rotations per minute. Calculate:

a) the linear speed.

b) the angular speed.

c) the centripetal acceleration.

6. What is the angular velocity of the earth around its axis? What is the linear velocity of a point situated at the equator? The radius of the earth is supposed to be 6400km.

7. The motion of the earth is considered as a rotation about its axis.

Find, for a point located in Paris (latitude 45°),

a) The angular velocity.

b) Linear velocity.

c) Centripetal acceleration.

8. Two bodies A and B describe in the same direction, the same circle of radius 10cm with constant angular velocities W_A = 10 rad/s and W_B = 11 rad/s. The motion starts when they are at the origin.

a) After how many seconds do they coincide again for the first time?

b) What is the distance travelled by A?

9. The artificial satellite syncom appears motionless in the sky and its trajectory is circular at the height of 35,700km. What is its speed? The radius of the earth is 6400km.

10. What time is it, after 12:00 the watch hands make an angle of 180° for the first time?

11. How many minutes after 4:00, watch hands coincide for the first time?

12. What time is it, after 3:00, the watch hands make a right angle for the first time?

13. An engine having a speed of 4000 rotations per minute decelerates during 8s till the stop. How many rotations does it make in that time?

14. Let a uniformly decelerated circular motion of deceleration 0.5 rads2. At t = 1 sec, the angular velocity has the magnitude of 1rad/s and the body is at the point **P/4**. Find the equation of the motion.

15. Let $\theta = 5 + 4t - t^2$ be the equation of a circular motion of radius 0.05m.

a) determine the angular velocity at t = 0 and t = 2.

b) determine its angular acceleration.
c) determine its acceleration and the linear velocity at $t = 0$ and $t = 2$s.
16. A punctual moving object describes a circular trajectory of radius r= 18m. The curvilinear displacement is given by $S=3t^2$, where S is in meter and t in seconds. Calculate the acceleration at $t = 2$s.
17. During 5s a wheel doubles its angular velocity and executes 120 rotations. What are the magnitudes of the angular velocities at the beginning and the end of the process?

Extension questions

1. An electric motor is switched off and its angular velocity decreases uniformly from 900 rotations to 400 rotations in 5s.
a) Find the angular acceleration in rotations/sec2 and the number of rotations done by the motor in the time interval of 5s.
b) How long does it take the motor to stop if the angular acceleration remains constant and equal to the one in (a)?

Dynaics of circular motion, centripetal force

1. Compute the centripetal force applied on a wheel of mass 1000kg, assuming that its diametre is 3m and it turns with a speed of 300 rotations per minute.
2. A train of 105kg travels with a speed of 70km/hand reaches a bend of radius 500m. Find the value of the centripetal force.
3. A frigate bird is soaring in a circular path. Its bank angle is estimated to be 25° and it takes 13s for the bird to complete one circle.
4. How fast is the bird flying?
5. What is the radius of the circle?
6. A 1000kg car rounds a curve on a flat road of radius 50m at a speed of 50 km/h. Will the car make the turn if :
a) The pavement is dry and the coefficient of static friction is 0.60,
b) The pavement is icy and the coefficient is 0.20? Calculate the speed required for a satellite moving in a circular orbit 200km above the earth's surface.
7. What is the maximum speed with which a 1300kg car can round a turn of radius 95m on a flat road if the coefficient of friction between tires and road is 0.55? Is this result independent of the mass of the car?
8. How large must the coefficient of friction be between the tires and the road if a car is to round a level curve of radius 62m at a speed of 55km/h?
9. If a curve of radius of 60m is properly banked for a car traveling 60km/h, what must be the coefficient of static friction for a car not to skid when traveling at 90km/h?
10. A 1200kg car rounds a curve of radius 65m banked at an angle of 14°. If the car is traveling at 80km/h, will a friction force be required? If so, how much and in which direction?
11. A vehicle of mass 1000kg is moving on a bridge which has the shape shown on the figure below. The radius is of 50m and the speed is 15m/s Find the magnitude of the force exerted by the vehicle on the bridge if the car is on the top of the bridge.

Figure showing a car moving on a banked path

12. A mass m_1 on a frictionless table is attached to a hanging mass m_2 by a cord through a hole in a table (see the figure). Find the speed with which $m1$ must move for $m2$ to stay at rest.

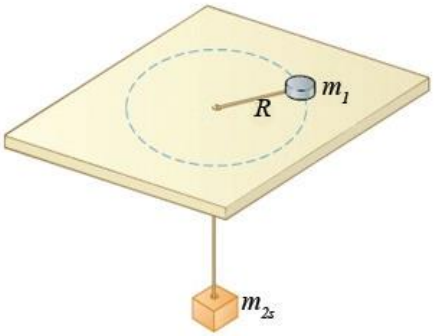

Figure showing two bodies (masses) connected

Extension questions

1. A mass rotates on a vertical circle at the end of a light string of 0.3m of length. Calculate:
a) The difference in kinetic energy between the upper and the lower point of the circle.
b) The difference in tension of the string between the upper and the lower point of the circle.
2. Read the passage below and answer the questions that follow: "Satellites which orbit 35,788km above the Earth's equator are said to be in geostationary orbit. Most telecommunication satellites are in this type of orbit. Other satellites are in solar orbit only and few hundreds of miles above the earth. These are said to be in low earth orbit. These are mainly military satellites which because of their low orbit can "see" things in great detail",
What is the difference between an artificial satellite and a natural satellite of the Earth?
c) Briefly explain three benefits of artificial satellites.
d) Describe what each of the following words used in the passage mean: (i) Geostationary, (ii) Low earth orbit.
e) Establish an expression for the velocity of geostationary satellites in terms of altitude *h*, earth radius *R* and acceleration due to gravity at the earth's surface *g* and then find its numerical value.
3. a) An object is moving in a circle with constant speed. What is the direction of the net force acting on this object?
b) What is the net force required to make an object of 40kg
accelerate at a rate of 2m/s?