Higher Grade Physics

OUR DYNAMIC UNIVERSE

Gravitation

Projectiles

1. A stone is dropped down a deep well and strikes the water 3.0 s later.
   (a) How deep is the well?
   (b) At what speed does the stone enter the water?

2. A teacher throws his pay cheque, wrapped around a stone, from the Kingston Bridge. If the initial velocity of the stone is 15 ms^{-1} and it takes 2.5 s to reach the water, what is the height of the bridge?

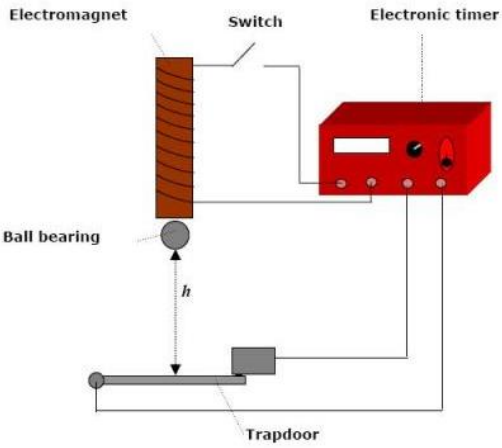
3. A stone dropped from the top of a cliff reaches the sea travelling at 25 ms^{-1}.
   What is the height of the cliff?

4. A stone, thrown vertically downwards from the top of another cliff at 5 ms^{-1}, reaches the sea travelling at 35 ms^{-1}.
   (a) What is the height of the cliff?
   (b) What is the time of flight?

5. Yet another stone is thrown vertically down a well at 5 ms^{-1}.
   (a) Calculate the speed of the stone as it reaches the water surface 60 m below.
   (b) How long does it take for the stone to reach the water?

6. An arrow is fired vertically upwards at 40 ms^{-1}.
   (a) How long does it take to reach its maximum height?
   (b) What is the maximum height?

7. At what vertical speed should an arrow be fired in order to reach a height of 180 m?

8. 

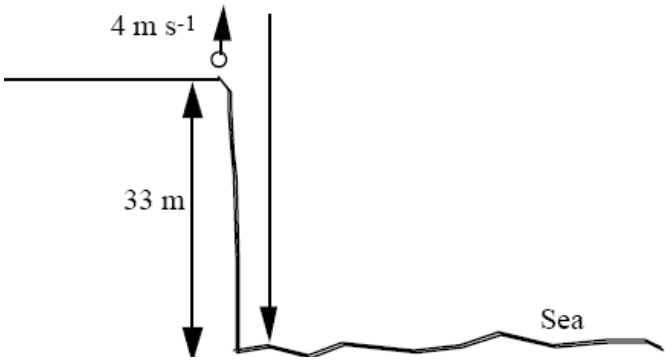
In an experiment to find the acceleration due to gravity (see the apparatus opposite) a steel ball falls from rest through 40 cm.

The time taken is 0.29 s.

What is the value for the acceleration due to gravity?

9. A marble is thrown vertically upwards at 20 ms^{-1} from the edge of a 105 m high cliff and eventually lands in the sea at the foot of the cliff.
   (a) What is the speed of the marble when it lands in the sea?
   (b) How long does the marble take to reach the cliff foot?
   (c) What is the maximum height above the sea reached by the marble?

10. A ball is thrown upwards from the side of a cliff as shown below.



(a) Calculate: i) the height of the ball above sea level after 2 s
ii) the ball's velocity after 2 s.

(b) What is the total distance travelled by the ball from launch to landing in the sea?

11. A helicopter is rising vertically at a steady speed of 5.0 ms^{-1} when James Bond drops from it. He reaches the ground 2.0 s later.
(a) What is his speed when he reaches the ground?
(b) What is the height of the helicopter when he jumps?
(c) What is his maximum height above the ground?

12. A Darth Vader hot air balloon rises vertically at a steady speed. When it is 80 m above the ground, an object is released. If the object hits the ground 5 s later, calculate the rising speed of the balloon.

13. A stone is thrown horizontally from the top of a cliff at 40 ms^{-1} and lands in the sea 3.0 s later.
(a) How far from the foot of the cliff does it land?
(b) What is the height of the cliff?

14. A projectile is fired horizontally from the edge of a cliff at 12 ms^{-1} and hits the sea 60 m away.
Find : (a) the time of flight
(b) the height of the starting point above sea level.

15. A car drives over the edge of a 125 m high cliff and lands in the sea 75 m from the cliff foot.
(a) How long does the car take to land?
(b) How fast is the car travelling when it goes over the edge?

16. In ***question 15***, at the instant the car hits the sea, what is
    (a) the horizontal component of the cars velocity
    (b) the vertical velocity
    (c) the resultant velocity of the car (magnitude and direction)?

17. A box is released from a plane travelling with a horizontal velocity of 300 ms^{-1} and a height of 300 m, find :
    (a) how long it takes the box to hit the ground
    (b) the horizontal distance between the point of impact and the release point
    (c) the position of the plane relative to the box at the time of impact.

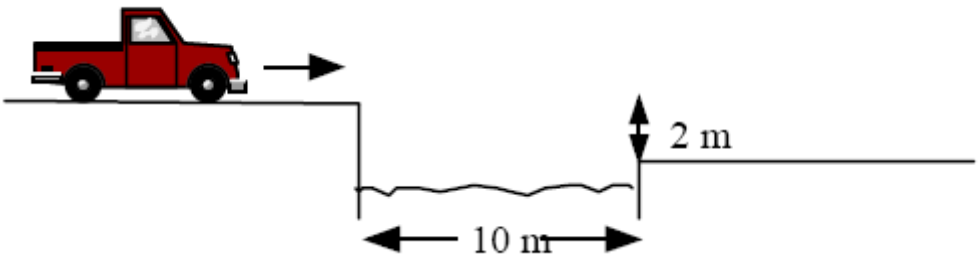
18. A rifle is aimed directly at a target which is a horizontal distance of 120 m away.
    (a) Explain why the bullet does not the strike the target (you may use a sketch).
    (b) If the bullet velocity is 240 ms^{-1}, by what vertical distance does it miss the target?

19. A ball is projected horizontally at 15 ms^{-1} from the top of a vertical cliff. It reaches the ground 45 m from the foot of the cliff.

    (a) Draw graphs, giving appropriate numerical values of the balls
        i) horizontal speed against time
        ii) vertical speed against time, for the period between projection until it hits the ground.

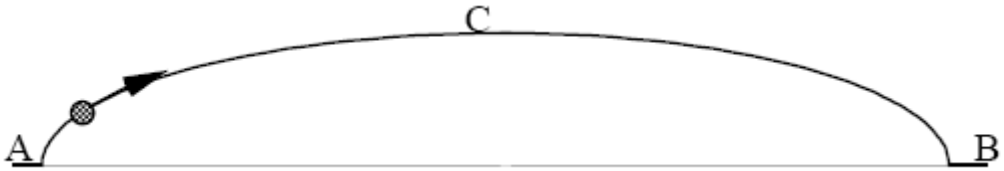
    (b) Use a vector diagram, to find the resultant velocity (magnitude and direction) of the ball 2 s after its projection.

20. A stunt driver hopes to jump across a canal of width 10 m.
    The drop to the other side is 2 m as shown.

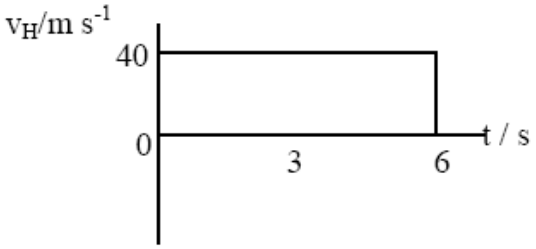


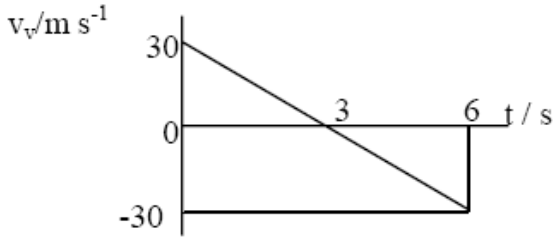
    (a) Calculate the horizontal speed required to make it to the other side
    (b) State any assumptions you have made.

21. A projectile is fired across level ground taking 6 s to travel from A to B.
The highest point reached is C. Air resistance is negligible.



Velocity - time graphs for the flight are shown below.





(a) Describe:
i) the horizontal motion of the projectile
ii) the vertical motion of the projectile?
(b) Use a vector diagram, to find the velocity (including the angle) at which the projectile was fired from point A.
(c) Find the velocity at position C. Explain why this is the smallest velocity of the projectile.
(d) Calculate the height of the projectile at point C.
(e) Find the range AB.

22. A cannon fires a shell at a target which is a horizontal distance of 7.2 km away. The shell emerges from the muzzle with a horizontal velocity of 120 ms^{-1} and an unknown vertical velocity.
(a) How long does the shell take to reach the target?
(b) What is the initial vertical velocity of the shell?

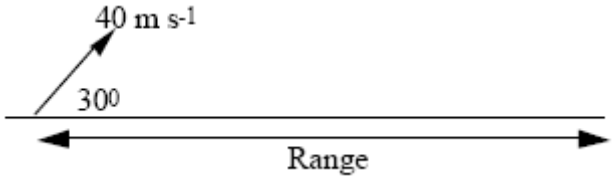
23. A projectile has an initial horizontal velocity of 60 ms^{-1} and an initial vertical velocity of 80 ms^{-1}.
(a) What is the time of flight of the projectile?
(b) What is the horizontal distance travelled?
(c) What is the maximum height reached?

24. A shell is fired with initial horizontal and vertical components of 100 ms^{-1} and 40 ms^{-1} respectively. At a distance of 600 m from the cannon is a building which is 55 m high. Does the shell clear the building and, if so, by how much?

25. A shell emerges from the muzzle of a gun at a velocity of 240 ms^{-1} and at an angle of 30^{o} above the horizontal. What are the initial horizontal and vertical components of the velocity?

26. A projectile is launched with an initial velocity of 100 ms^{-1} at an angle of 30 ^{o} above the horizontal. Find
    (a) the initial horizontal and vertical components of the velocity
    (b) the time of flight
    (c) the horizontal range.

27. An object of mass 5 kg is propelled with a speed of 40 ms^{-1} at an angle of 30 ^{o} to the horizontal.

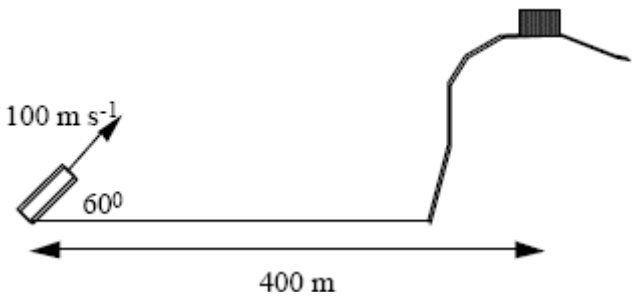


    Find:
    (a) the initial horizontal and vertical components of the velocity
    (b) the maximum height reached
    (c) the time of flight for the whole trajectory
    (d) the horizontal range of the object.

28. A bullet leaves the barrel of a gun travelling at 240 ms^{-1}. What is the range of the bullet if the angle of elevation of the gun is
    (i) 45 ^{o} (ii) 60 ^{o}

29. A projectile is launched with an initial velocity of 130 ms^{-1} and reaches a maximum height of 125 m. Find :
    (a) the initial vertical component of the velocity
    (b) the initial horizontal component of the velocity
    (c) the angle of projection
    (d) the range.

30. A missile is launched at 60° to the ground and strikes a target on a hill as shown below.



    If the initial speed of the missile was 100 ms^{-1} find:
    (a) the time taken to reach the target
    (b) the height of the target above the launcher.

31. Explain why a satellite that is travelling at a constant speed is accelerating.

Gravity and Mass

32. State the inverse square law of gravitation.

33. Show that the force of attraction between two large ships, each of mass $5{\cdot}00 \times 10^{7}$ kg and separated by a distance of 20 m, is 417 N.

34. Calculate the gravitational force between two cars parked 0·50 m apart. The mass of each car is 1000 kg.

35. In a hydrogen atom an electron orbits a proton in a circle with a radius of $5{\cdot}30 \times 10^{-11}$ m. The mass of an electron is $9{\cdot}11 \times 10^{-31}$ kg and the mass of a proton is $1{\cdot}67 \times 10^{-27}$ kg. Calculate the gravitational force of attraction between the proton and the electron in a hydrogen atom.

36. The distance between the Earth and the Sun is $1{\cdot}50 \times 10^{11}$ m. The mass of the Earth is $5{\cdot}98 \times 10^{24}$ kg and the mass of the Sun is $1{\cdot}99 \times 10^{30}$ kg. Calculate the gravitational force between the Earth and the Sun.

37. Two protons exert a gravitational force of $1{\cdot}16 \times 10^{-35}$ N on each other. The mass of a proton is $1{\cdot}67 \times 10^{-27}$ kg. Calculate the distance separating the protons.