**1.** A particle *P* of mass 0.5 kg is moving under the action of a single force **F** newtons. At time   
*t* seconds, **F** = (1.5*t* 2 – 3)**i** + 2*t***j**. When *t* = 2, the velocity of *P* is 

(*a*) Find the acceleration of *P* at time *t* seconds. **(2)**

(*b*) Show that, when *t* = 3, the velocity of *P* is  **(5)**

When *t* = 3, the particle *P* receives an impulse **Q**N s. Immediately after the impulse the velocity of *P* is  Find

(*c*) the magnitude of **Q**, **(3)**

(*d*) the angle between **Q** and **i**. **(3)**

**2.** At time *t* seconds (*t* ≥ 0), a particle *P* has position vector **p** metres, with respect to a fixed origin *O*, where **p** = (3*t*2 – 6*t* + 4)**i** + (3*t*3 – 4*t*)**j**.

Find

(*a*) the velocity of *P* at time *t* seconds, **(2)**

(*b*) the value of *t* when *P* is moving parallel to the vector **i**. **(3)**

When *t* = 1, the particle *P* receives an impulse of (2**i** – 6**j**) N s. Given that the mass of *P* is 0.5 kg,

(*c*) find the velocity of *P* immediately after the impulse. **(4)**

**3.** A particle *P* moves along the *x*-axis in a straight line so that, at time *t* seconds, the velocity of *P* is *v* m s–1, where

*v* = 

At *t* = 0, *P* is at the origin *O*. Find the displacement of *P* from *O* when

(*a*) *t* = 6, **(3)**

(*b*) *t* = 10. **(5)**

**4.** A small ball is projected from a fixed point *O* so as to hit a target *T* which is at a horizontal distance 9*a* from *O* and at a height 6*a* above the level of *O*. The ball is projected with speed √(27*ag*) at an angle *θ* to the horizontal, as shown in the diagram. The ball is modelled as a particle moving freely under gravity.

(*a*) Show that tan2 *θ* – 6 tan *θ* + 5 = 0. **(7)**

The two possible angles of projection are *θ*1 and *θ*2, where *θ*1 > *θ*2.

(*b*) Find tan *θ*1 and tan *θ*2. **(3)**

The particle is projected at the larger angle *θ*1.

(*c*) Show that the time of flight from *O* to *T* is . **(3)**

(*d*) Find the speed of the particle immediately before it hits *T*. **(3)**



|  |  |  |
| --- | --- | --- |
|  |  |  |
| **2.** | (a) | M1 A1 **(2)** |
|  |  |  |
|  | (b) | M1 |
|  |  | DM1 A1 **(3)** |
|  |  |  |
|  | (c)  ft their | B1ft |
|  | (+/-) | M1 |
|  |  | M1 A1 **(4)** |
|  |  | **[9]** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **3**(a) | , | M1 |
|  |  | A1 |
|  | (m) | A1 |
|  |  | (3) |
| (b) |  | B1 |
|  | t = 6, s = “36” | M1\* |
|  |  | A1 |
|  | At (m) | d\*M1 |
| A1 |
|  |  | (5) |
|  |  | **[8]** |

|  |  |  |
| --- | --- | --- |
| **7.** |  | **M1** |
| **(a)** |  | **A1** |
|  |  | **M1** |
|  |  | **A1** |
|  |  | **DM1** |
|  |  | **DM1** |
|  |  | **A1 (7)** |
| **(b)** |  |  |
|  |  | **M1** |
|  |  | **A1 A1 (3)** |
| **(c)** |  | **M1**  **A1ft** |
|  | **Answer given**\* | **A1**  **(3)** |
| **(d)** |  | **M1**  **A1** |
|  |  | **A1 (3)** |
|  |  | **[16]** |