KEY

PHYSICS 12 Name: KEY

/30

FREE FALL AND PROJECTILE MOTION

In-Class Assignment

Only full solutions with diagrams and assumptions clearly stated will earn a full mark.

1. a) An object falls from a 350.0 m height. How much time does it need to land on the ground below? [5]

G: $\vec{d_y} = -350m$

↑+ ↓− $\vec{a_y} = -9.8 m/s^2$

R: $t_{ff} = ?[s]$

A: $t_{ff} = \sqrt{\frac{2d_y}{a_y}}$

S: $t_{ff} = \sqrt{\frac{2(-350.0)}{-9.8}}$

$\doteq 8.5 s$

S: It takes 8.5 s to fall to the ground.

b) What assumptions do you make?

→ on Earth, no obstacles, no other forces than $\vec{F_g}$, close to surface.

2. a) Consider a 25.0-kg projectile shot at 40.0 m/s. If it lands at the same level it was shot from after 6.60 seconds, what is its initial velocity? [5]

G: $m = 25.0 kg$

↑+ ↓− $t_{air} = 2t_{hmax} = 6.60 s$

$\vec{a_y} = -9.8 m/s^2$

$v_i = 40.0 m/s$

R: $\theta = ? [°]$

A: $v_{fy} = v_{iy} + a_y t_{hmax} \rightarrow v_{iy} = v_{fy} - a_y t_{hmax}$

$t_{hmax} = \frac{t_{air}}{2}$

$\theta = \sin^{-1}\left(\frac{v_{iy}}{v_i}\right)$

S: $v_{iy} = 0 - (-9.8)\left(\frac{6.60}{2}\right) = 32.34 m/s$

$\theta \doteq \sin^{-1}\left(\frac{32.34}{40.0}\right) \doteq 54°$

S: $\vec{v_i} = 40.0 m/s$ 54° above horizontal.

b) What is the range of the projectile?

$d_x = v_{ix} \cdot t_{air} = \|v_i\| \cdot \cos\theta \cdot t_{air}$

$= (40.0)(\cos 54°)(6.60)$

$\doteq 1.6 \times 10^2 m$

[3] 3. a) A 10.0-kg object thrown strictly upwards with velocity of 15.0m/s [U] spends 10.0 s in the air. What is the acceleration due to gravity?

G: $m = 10.0 kg$

$\vec{v}_i = 15.0 m/s [U]$

↑+ ↓-

$t_{air} = 10.0 s$

R: $a = ? [m/s^2]$

A: • not on Earth

• $t_{hmax} = \frac{t_{air}}{2}$

S: $v_{fy} = v_{iy} + a_y t$

$a_y = \frac{v_{fy} - v_{iy}}{t_{hmax}}$

S: $a_y = \frac{0 - 15.0}{\frac{10.0}{2}}$

$\vec{a}_y = -3.0 m/s^2$

S: the acceleration due to gravity is $3.0 m/s^2$ [D].

b) What assumptions do you make?

→ landing and launching level are the same

→ only F_g acts on the object

→ free path

→ not on Earth

$V_{iy} = 50.0 \sin 30^\circ$
$= 25 \text{ m/s}$

[10]

S: The object lands 22 m above the launching level 1.7×10^2 m [R]
$z = 1.7\times10^2$ m.

4. **Where does an object land if it is shot at 50.0 m/s at 30° above horizontal and it takes 4.0 s for it to hit the ground?**

G: $\vec{a}_y = -9.8 \text{ m/s}^2$

↑+ ↓− $\vec{v}_i = 50.0$ m/s 30° above horizontal

$t_{air} = 4.0$ s

R: $\vec{d}_x = ?$ [m]

$\vec{d}_y = ?$ [m]

S: $\vec{d}_y = v_{iy} t_{ff} + \frac{1}{2} a_y t_{ff}^2$

$\vec{d}_y = 0 + \frac{1}{2}(-9.8)(1.4490)^2$

$d_y = -10.2878$ m

$h_{max} = \frac{0^2 - v_{iy}^2}{2(-9.8)}$

$= 31.8878$ m

$y = 31.8878 - 10.2878$

$\doteq 22$ m

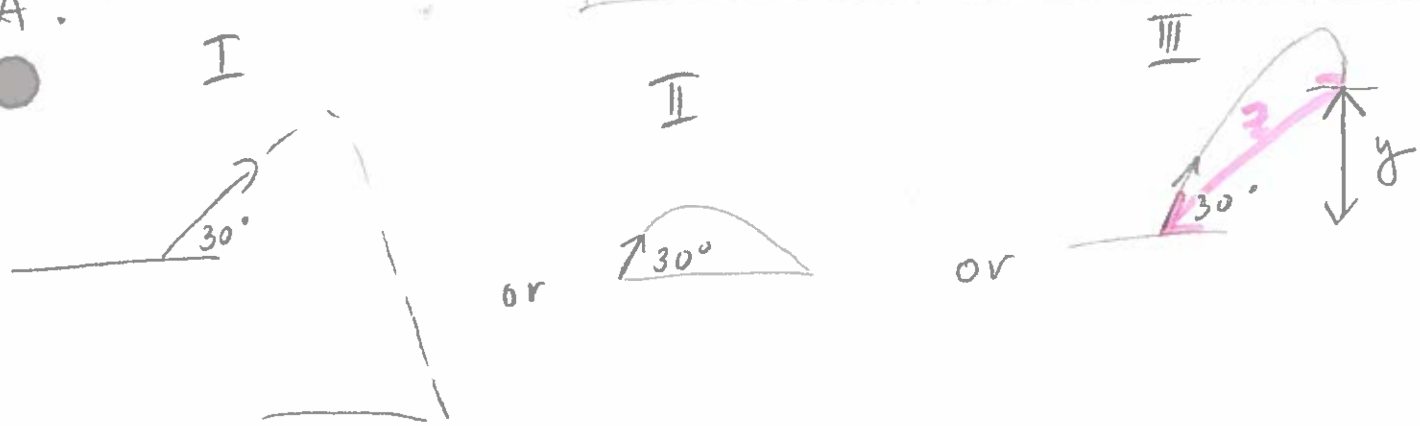
$d_x = (50.0)(\cos 30^\circ)(4.0)$

$= 173.2051$ m

$= 1.7\times10^2$ m

$z = \sqrt{173^2 + 22^2} = 174$ m

A:



$t_{air} = t_{hmax} + t_{ff}$

S: $t_{hmax} = \frac{0 - V_{iy}}{a_y}$

$= \frac{0 - (50.0)(\sin 30^\circ)}{-9.8}$

$\doteq 2.5510$ s

$t_{ff} = t_{air} - t_{hmax}$

$= 4.0 - 2.5510$

$= 1.4490$ s

⇒ III is the scenario

[7] $\vec{V}_{iy} = \vec{V}_i$

5. If you triple the velocity an object is thrown strictly upwards, what happens to the object's maximum height and its time spent in the air? **Support your reasoning with calculations.**

(B) Before

$v_{i_{(B)}} = v_{i_{(B)}}$

(A) After

$v_{i_{(A)}} = 3 v_{i_{(B)}}$

Before:

$$t_{hmax} = \frac{0 - V_{iy}}{a_y} = \frac{-V_{i_B}}{a_y}$$

After:

$$t_{hmax} = \frac{-3 v_i}{a_y} = 3 \cdot \frac{(-V_i)}{a_y} = 3 \cdot t_{hmax_{(B)}}$$

Before:

$$h_{max} = \frac{0^2 - V_{iy}^2}{2 \cdot a_y} = \frac{-V_i^2}{2a_y}$$

After:

$$h_{max} = \frac{0^2 - (3 v_{i_B})^2}{2a_y} = \frac{-9 v_{i_B}^2}{2a_y} = 9 \cdot \left(\frac{-V_{i_B}^2}{2a_y}\right) = 9 \cdot h_{max_{(B)}}$$

∴ time to reach hmax will triple and the maximum height will be 9 times greater.