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Course: PHYSICAL PROBLEM SOLVING! | Date: September 24, 2022

Exercise 1

- I)No, the heavier object falls down faster in the gravity field.For instance,consider two obects like vertical pen with small mass and horizontal calculator both are falling down from the some point,and pen is will hits the ground first.this is due to the resistance of calculator is low which leads to have the high cross section area compare to that of pen.

- II) We are given a parachutist launches from the top of an airplane and it has a mass of 70kg and that he drops at a constant speed.

see the diagram is

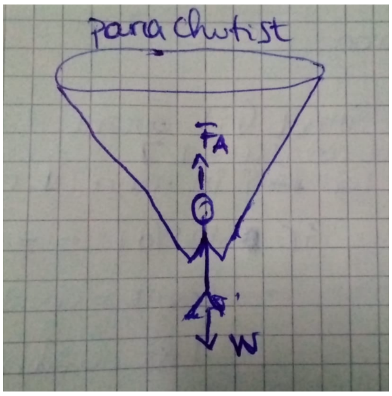

Figure 1: parachitus and person diagram

From the diagram, the forces acting on parachutist are Air resistance force F_A and Weight W. we are asked to find the air resistance force F_A knowing that mass $m = 70kg$ and he drop at constant speed V.
This means that at constant V,the accleration is zero.

$\sum F(net) = 0$ This means that

$$F_A + (-W) = 0 \tag{1}$$

$$W = m * g \tag{2}$$

where g is gravity with $g = 9.81 m/s^2$ and m is mass in kg.

replacing 2 in 1

$$F_A - m * g = 0 \tag{3}$$
$$F_A = m * g \tag{4}$$

$$F_A = (70 * 9.81) \tag{5}$$
$$= 686.7N \tag{6}$$

III) On planet X, the gravitational acceleration is $-10\lambda m/s^2$ where λ is a positive constant. A rock is launched vertically upwards from groung level with the initial velocity $v_0 = 80m/s$.

1. Find the time taken for the rock to return to the groung again for $\lambda = 4$.

2. Find the maximum height reached by the rock.

3. Find the velocity with which it hits the ground.

Solution

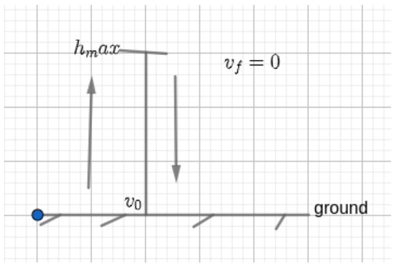

Figure 2: rock launched vertically upwards

From **??** to calculate the time T_t taken for the rock to return to the ground, first we find the time t taken for the rock to reach on maximum heigth.

$$v_f = v_0 - gt \tag{7}$$

where v_0 is inital velocity,g is gravity. $g = -10\lambda m/s^2$ this sign(-) shows the direction $\lambda = 4$.

From the 7 we are going to replace the values of these variables.

$$v_f = v_0 - gt \tag{8}$$
$$0 = 80 - (10 * 4)t \tag{9}$$
$$t = \frac{80}{40} \tag{10}$$
$$= 2s \tag{11}$$

So, the time taken for the rock to return to the ground is:

$$T_t = 2 * t \quad (12)$$
$$T_t = 4s \quad (13)$$

2.solution
For finding the maximum height $h_(max)$ reached by the rock.
Given data
$v_0 = 80m/s$,$g = -10\lambda m/s^2$,$\lambda = 4$ and time taken to reach at maximum $t = 2s$
we know that

$$y = v_0 * t - \frac{1}{2}g * t^2 + y_0 \quad (14)$$
$$h(max) = y - y_0 \quad (15)$$

this means that

$$\begin{aligned} h_(max) &= v_0 * t - \frac{1}{2}g * t^2 && (16)\\ &= (80 * 2) - \frac{1}{2} * 10 * 4 * 2^2 && (17)\\ &= (160 - 80)m && (18)\\ &= 80m && (19) \end{aligned}$$

3 solution
We are asked to find the velocity with which it hits the ground.As we have seen from 7 and from the maximum height to reach the ground, the final velocity is equal to initial velocity with different direction.
therefore,

$$v = v_0 - g \times t$$

By replacing $v_0 = 80m/s$,the velocity v to hits the ground is

$$v = -80m/s$$

1 Exercise2

We have a basketball player having,$h = 210cm$ tall,throws a ball at angle $\Theta = 30^0$ to the horizontal.The basket has height,$H = 304cm$ tall and the player is positioned at the distance $D = 402cm$ from the basket.we are asked to find the initial speed v_0 should the player throw the ball so that it passes through the center of the basket.

The diagram is

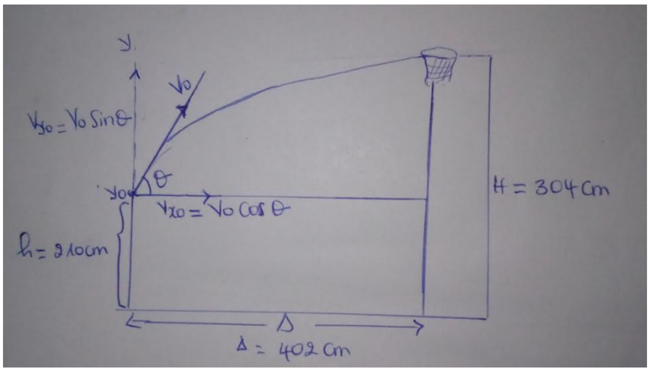

Figure 3: basketball

Given data:

$$\begin{aligned} \Theta &= 30^\circ \\ H &= 304cm = 3.04m \\ h &= 210cm = 2.10m \\ D &= 402cm = 4.02m \end{aligned}$$

From the Newton's Law of motion
we know that

$$Y = V_(y_0) \times t - \frac{1}{2} g \times t^2 + y_0 \tag{20}$$

$$X = V_{x_0} \times t + x_0 \tag{21}$$

For finding the initial speed,V_0,
from y axis

$$V_{y_0} = V_0 \sin\Theta \tag{22}$$

from $x$axis

$$V(x_0 = V_0 \cos\Theta \tag{23}$$

From **??**

$$\begin{aligned} H = Y &= 3.04m \\ h = y_0 &= 2.10m \\ D = X - x_0 &= 4.02m \end{aligned}$$

we are going to replace these values in 20 and 21

$$H = V_{y_0} \times t - \frac{1}{2} \times g \times t^2 + h \tag{24}$$

$$D = V_{x_0} \times t \tag{25}$$

replace 22 and 23 in 24 and 25
we get

$$H - h = V_0 \sin\Theta \times t - \frac{1}{2} \times g \times t^2 \tag{26}$$

$$D = V_0 \cos\Theta \times t \tag{27}$$

finding t from 27

$$t = \frac{D}{V_0 \cos \Theta} \tag{28}$$

replacing 28 in 26

$$\begin{aligned} H - h &= V_0 \sin \Theta \times (\frac{D}{V_0 \cos \Theta} - \frac{1}{2} \times g \times \frac{D^2}{V_0^2 \cos^2 \Theta} & (29) \\ &= D \tan \Theta - \frac{g \times D^2}{2 \times (V_0)^2 \cos^2 \Theta} & (30) \end{aligned}$$

for finding the initial velocity,V_0
from 29

$$V_0^2 = -\frac{g \times D^2}{2(H - h - D \tan \Theta) \cos^2 \Theta} \tag{31}$$

$$V_0 = \sqrt{-\frac{g \times D^2}{2(H - h - D \tan \Theta) \cos^2 \Theta}} \tag{32}$$

replacing the values of H,h,D and Θ in 32
we get

$$\begin{aligned} V_0 &= \sqrt{-\frac{9.81 \times (4.02)^2}{2(3.04 - 2.10 - 4.02 \tan 30) \cos^2 30}} & (33) \\ &= \sqrt{\frac{-158.533524}{-2.071422123}} & (34) \\ &= \sqrt{76.5336636} & (35) \\ &= 8.74835 m/s & (36) \end{aligned}$$

Exercise3

A)

Given data

A block slides without friction down a fixed,inclined plane with angle.

Answer a

The forces acting on the block are:

- Normal force F_N

- Gravitation force(weight),W

Answer b

we are asked to calculate the acceleration a of the block.

here our motion is done on X axis
the force acting on it is $mg \sin 60$. we know that

$$\sum F_x = m \times a \tag{37}$$

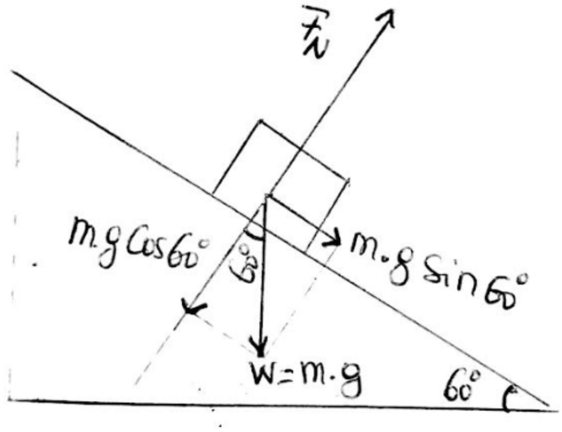

Figure 4: inclined plane

where a is acceleration and m is mass of block.

This means that

$$m \times a = m \times g \sin 60 \tag{38}$$

$$\begin{aligned} a &= \frac{m \times g \sin 60}{m} && (39) \\ &= g \times \sin 60 && (40) \\ &= 9.81 \times 0.866025403 && (41) \\ &= 8.495 m/s^2 && (42) \end{aligned}$$

answe c
for finding the velocity,V and position,X.
we have seen that $a = g \times \sin 60$

and knowing that $a = \frac{dV}{dt}$

$$dV = adt \tag{43}$$

integrate on both sides,

$$\begin{aligned} \int_{V_0}^{V} dV &= \int_0^t g \sin 60 \\ V_{V_0}^{V} &= g \times t sin 60 \end{aligned}$$

$$V(t) = V_0 + g \times t sin 60$$

For finding the psition,X
we know that

$$\frac{dX}{dt} = V \tag{44}$$

we integrate both sides to find X

$$\int_{x_0}^{X} dX = \int_0^t V \tag{45}$$

we replace the V in 45

$$X(t) = V_0 t + \frac{gt^2}{2}\sin 60 + x_0 \tag{46}$$

answer B
for determining the acceleration,a, of a block now it is moving it is subjected to sliding friction.

Given data

- $F_f = \mu F_N$
- $\mu = 0.3$
- $\alpha = 60°$

the diagram is below on Y axis

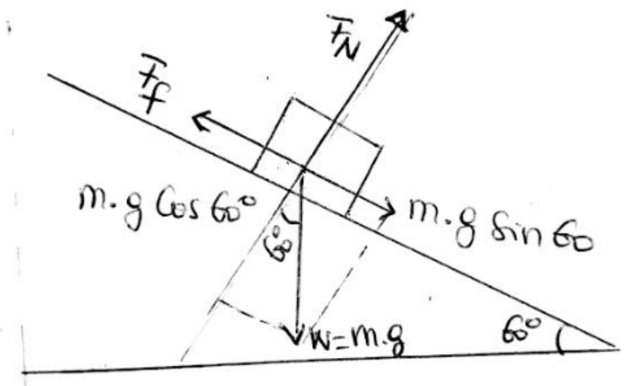

Figure 5: inclined plane with friction force

$$\begin{aligned} F_N - m \times g\cos 60 &= 0 \\ F_N &= m\ timesg\cos 60 \end{aligned}$$

the forces acting o X axis,

$$\Sigma F_X = m \times g\sin 60 - F_f$$

knowing that $\Sigma F_X = m * a$

this measn that

$$m \times a = m \times g - F_f$$

We have given that $F_f = \mu F_N$,and $F_N = m \times g \cos 60$
so replace it in the above equation

$$m \times a = m \times g \sin 60 - \mu F_N \tag{47}$$
$$m \times a = m \times g \sin 60 - \mu \times m \times g \cos 60 \tag{48}$$
$$a = g[\sin 60 - \mu \cos 60] \tag{49}$$

then replace the values of $\mu = 0.3$ and $g = 9.81m/s^2$ in 49

$$a = 9.81[\sin 60 - 0.3 \cos 60]$$

$$a = 7.0235m/s^2$$

For finding the velocity,V and position,X
from the above calculation, we have seen that acceration,

$$a = g[\sin 60 - \mu \cos 60]$$

$$\frac{dV}{dt} = a$$

$$dV = adt$$

we integrate both sides

$$\int_{v_0}^{V} dV = \int_0^t g[\sin 60 - \mu \cos 60]dt$$

$$[V]_{v_0}^{V} = [gt[\sin 60 - \mu \cos 60]]_0^t$$

$$V(t) = g(\sin 60 - \mu \cos 60)t + v_0$$

replacing the values of $g = 9.81m/s^2$ and $\mu = 0.3$

we get

$$V(t) = 9.81(\sin 60 - 0.3 \cos 60)t + v_0$$

$$V(t) = ((7.0242)t + v_0)m/s^2$$

for finding the position ,X,

we have seen that

$$\frac{dX}{dt} = V$$

$$dX = Vdt$$

by integrating both sides,we get

$$\int_{x_0}^{X} = \int_{0}^{t} Vdt$$

$$V = g(\sin 60 - \mu \cos 60)t + v_0$$

$$[X]_{x_0}^{X} = \int_{0}^{t} (g(\sin 60 - \mu \cos 60)t + v_0)dt$$

$$X - x_0 = g(\sin 60 - \mu \cos 60)\frac{t^2}{2} + v_0 t$$

by replacing the values of $g = 9.81m/s^2$,and $\mu = 0.3$

$$X(t) = \frac{9.81(\sin 60 - 0.3 \cos 60)}{2} t^2 + v_0 t + x_0$$

$$X(t) = (3.51t^2 + v_0 t + x_0)m.$$

End.