PHYSOL EXAMINATION SERIES
CHAPTER 4- MOTION IN A PLANE
SUNDAY 04-07-2021 @ 7.00pm

PES03 **TIME: 1 HOUR**

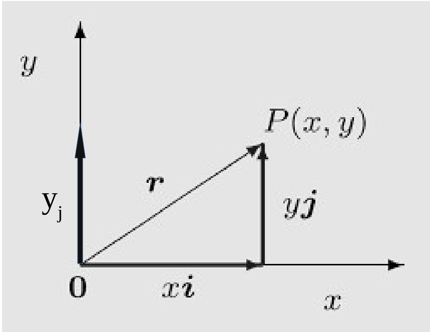
MAXIMUM SCORE:30

ANSWER KEY

1	Vectors	**1**
2	90^0	**1**
3	Zero Vector or Null vector	**1**
4	Acceleration	**1**

5	For a projectile launched with velocity v_o at an angle θ_o , the range is given by Range $R=\frac{u^2 \sin 2\theta_0}{g}$ Now, for angles, (45° + α) and (45° – α), 2θo is (90° + 2α) and (90° – 2α) , respectively. The values of sin (90° + 2α) and sin (90° – 2α) are the same, equal to that of cos 2α. Therefore, ranges are equal for elevations which exceed or fall short of 45° by equal amounts α.	**2**
6	(a) At highest point the acceleration remains same as acceleration due to gravity (b) At highest point, velocity becomes zero	**1** **1**
7	Yes. When ucosθ = $\frac{u}{2}$ Cosθ = 1/2 θ =60°.	**2**
8	- h = - 1/2 gt^2 h = 1/2 x 10 X 100 = 500m	**2**

9	(a) The unit vector of $\vec{A}$, $\hat{A}=\frac{\vec{A}}{\lvert\vec{A}\rvert}$	1
	(b) $\vec{A} = 4\hat{i}-3\hat{j}+\hat{k}$ Here $\lvert\vec{A}\rvert=\sqrt{A_x^2+A_y^2+A_z^2}$ $\lvert\vec{A}\rvert=\sqrt{4^2+(-3)^2+1^2}$ $\lvert\vec{A}\rvert=\sqrt{16+9+1}=\sqrt{26}$ There fore $\hat{A}=\frac{\vec{A}}{\lvert\vec{A}\rvert} = \frac{4\hat{i}-3\hat{j}+\hat{k}}{\sqrt{26}}$	2

10	a)  b) $\vec{r} = x\,\hat{i} + y\,\hat{j}$ c) $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$	1 1 1
11	We have $H = \frac{u^2 \sin^2\theta}{2g}$ & $R = \frac{u^2 \sin 2\theta}{g}$ When H= $\frac{R}{4}$ $\frac{u^2 \sin^2\theta}{2g} = \frac{1}{4}\frac{u^2 \sin 2\theta}{g}$ $\sin^2\theta = \frac{\sin 2\theta}{2}$ $\sin^2\theta = \frac{2\sin\theta\cos\theta}{2}$ $\frac{\sin\theta}{\cos\theta} = 1$ $\tan\theta = 1$ $\theta = 45^o$	3
12	Given 2usinθ /g= 5 usinθ= 25 Now. H = $u^2 Sin^2\theta / 2g$ = $25^2/2 \times 10$ = 31.25 m	3
13	a)**Expression for Maximum height(H):** We have $V^2 = u^2 + 2as$ Taking the vertical components; $V_y^2 = u_y^2 + 2a_y s_y$ Here Vy=0, u_y=usinθ , a_y=-g and S_y =H Therefore $0 = (u\sin\theta)^2 - 2gH$ $2gH = u^2 \sin^2\theta$ Maximum Height , $H = \frac{u^2 \sin^2\theta}{2g}$ **Expression for Time of flight (T):** We have $S = ut + \frac{1}{2}at^2$ Taking vertical components;	3

$$S_y = u_y t + \frac{1}{2} a_y t^2$$

Here $S_y=0$, $u_y=u\sin\theta$, $a_y=-g$ and t=T, time of flight.

Therefore $$0 = u\sin\theta T - \frac{1}{2} g T^2$$

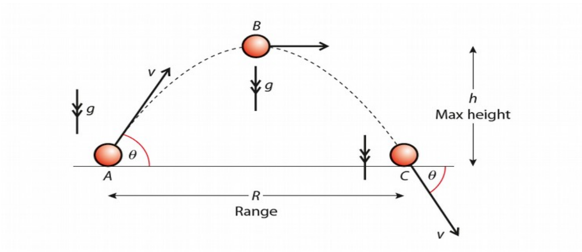
$$\frac{1}{2} g T^2 = u\sin\theta T$$

$$\frac{1}{2} g T = u\sin\theta$$

Time of flight $$T = \frac{2u\sin\theta}{g}$$

b) For Maximum horizontal range , angle of projection θ=45^{0}. 1

14 a) 1



b) **<u>Expression for the Range of a Projectile(R):</u>**

The product of horizontal component of velocity and time of flight gives the range of a projectile.

$$R = u_x \, x \, T$$

$$R = u\cos\theta \, x \, \frac{2u\sin\theta}{g}$$

$$R = \frac{u^2}{g} 2\sin\theta\cos\theta$$

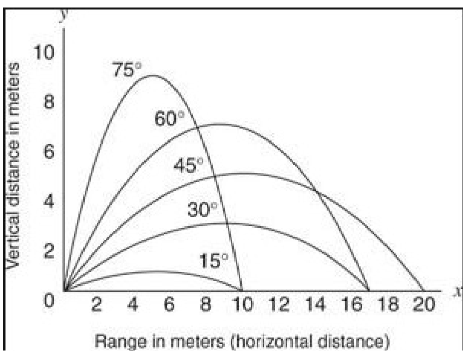
Therefore Range , $$R = \frac{u^2}{g} \sin 2\theta$$ 3

When θ=45^0, 2θ =90^0, then the range is maximum.

$$\therefore \quad R_{max} = \frac{u^2}{g}$$

An athlete throws javelin at an angle of 45^0 to get maximum range.

For a projectile the range will be same at an angle θ and (90-θ).(for example at 30^0 and 60^0, the range will be same for a projectile).



15 Given H=25m , u= 40 m/s. — **4**

$$H=\frac{u^2\sin^2\theta}{2g}=\frac{40^2\sin^2\theta}{2x9.8}=25m$$

$$\sin^2\theta=\frac{25x9.8x2}{40^2}=.30625$$

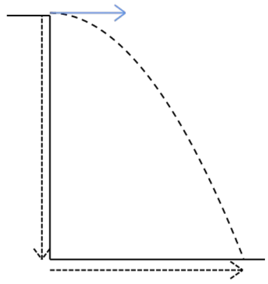
Therefore θ=33.6⁰

Range $R=\frac{u^2\sin 2\theta}{g}=\frac{40^2\sin 2(33.6)}{9.8}=150.5m$

16 (a) Horizontal displacement $S_x=u_x t$ because $a_x=0$ — **2**

Vertical displacement $S_y=\frac{1}{2}gt^2$ because $u_y=0$ $a_y=g$

t	1	2	3	4	5
S_x	40	80	120	160	200
S_y	5	20	45	80	125



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(b) Hight of the tower , $H=\frac{1}{2}gt^2=\frac{1}{2}x10x4^2$

H=80m.

17 a) Two Dimensional Motion — **1**

b) Given $y=x-\frac{x^2}{80}$ and We have $y=(\tan\theta)x-(\frac{g}{2u^2\cos^2\theta})x^2$

Comparing, we get

tanθ=1 Therefore θ=45⁰. — **2**

And $\frac{g}{2u^2\cos^2\theta}=\frac{1}{80}$

That is $\frac{u^2}{g}=80$

We have Maximum height $H=\frac{u^2\sin^2\theta}{2g}$

$$H=\frac{80}{2x2}=20m.$$

c)Here u= 37 m/s θ= 53.1° g=9.8 m/s²

u_x = ucos θ=37 cos (53.1)=37x 0.6=22.2m/s

u_y=usin θ=37 sin (53.1)=37x0.79=29.59 m/s.

The x-coordinate is given by — **2**

$S_x=u_x t+\frac{1}{2}a_x t^2=u_x t$ (a_x=0)

Therefore at t=2s, x=22.2 x 2=44.4 m

The y-coordinate is given by

$S_y=u_y t+\frac{1}{2}a_y t^2$

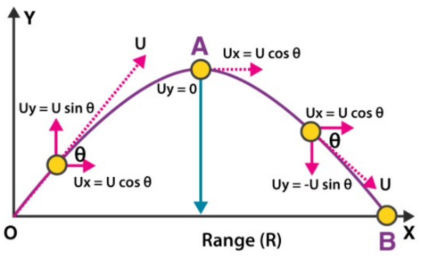
$y=29.59x2-\frac{1}{2}9.8x2^2$ (a_y=-g=-9.8 m/s²)

y=39.6m

Therefore the position of the ball when t = 2s is given by (44.4, 39.6)

18 a)Parabola 1

b)at its highest point 2



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c) On projection , the entire energy is kinetic energy (so P.E =0) = $\frac{1}{2} m v^2 = E$

At the highest point KE = $\frac{1}{2} m v^2 \cos^2(\theta)$

$= E \cos^2(\theta)$

PE at highest point = Total energy -KE

$= E - E\cos^2\theta$

$= E(1 - \cos^2\theta)$

$= E \sin^2\theta$