தேசிய வெளிக்கள நிலையம் தொண்டைமானாறு
மூன்றாம் தவணைப் பரீட்சை - 2024

National Field Work Centre, Thondaimanaru
3rd Term Examination - 2024

Grade 12(2024) **Combined Mathematics** **Marking Scheme**

1.

$ax^2+bx+c=0, \quad px^2+qx+r=0$

$\alpha+\beta = -\frac{b}{a}$ (5)

$\alpha\beta = \frac{c}{a}$

$(\alpha+\gamma)+(\beta+\gamma) = -\frac{q}{p}$ (5)

$(\alpha+\gamma)(\beta+\gamma) = \frac{r}{p}$

$(\alpha-\beta)^2 = \{(\alpha+\gamma)-(\beta+\gamma)\}^2$ (5)

$(\alpha+\beta)^2-4\alpha\beta = \{(\alpha+\gamma)+(\beta+\gamma)\}^2-4(\alpha+\gamma)(\beta+\gamma)$ (5)

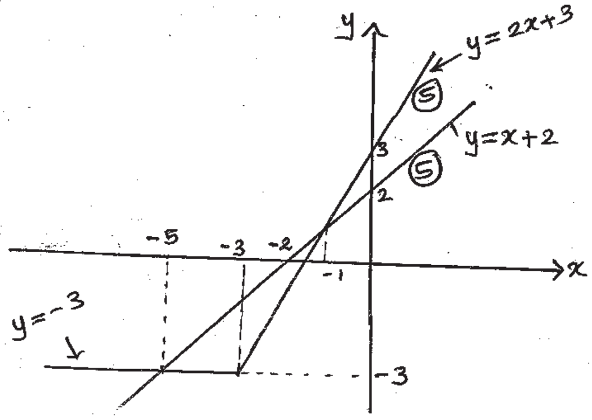
$\frac{b^2}{a^2}-4\frac{c}{a} = \frac{q^2}{p^2}-4\frac{r}{p}$ (5)

$\frac{b^2-4ac}{a^2} = \frac{q^2-4pr}{p^2}$.

$\boxed{25}$

2. $y = |x+3|+x$

$= \begin{cases} 2x+3 ; & x \geq -3 \\ -3 ; & x < -3 \end{cases}$



case (i) $x < -2$,

$\frac{|x+3|+x}{x+2} > 1 \Leftrightarrow |x+3|+x < x+2$

$-5 < x < -2$ —— (1) (5)

case (ii) $x > -2$

$\frac{|x+3|+x}{x+2} > 1 \Leftrightarrow |x+3|+x > x+2$

$x > -1$ —— (2) (5)

(5) $(1),(2) \Rightarrow -5<x<-2$ or $x>-1$ $\boxed{25}$

3.

$\lim\limits_{x\to 0} \frac{2\sin x - \sin 2x}{x^2(\sqrt{2+x}-\sqrt{2-x})}$ (5)

$= \lim\limits_{x\to 0} \frac{(2\sin x - 2\sin x\cos x)(\sqrt{2+x}+\sqrt{2-x})}{x^2(2+x-2+x)}$ (5)

$= \lim\limits_{x\to 0} \frac{\cancel{2}\sin x(1-\cos x)(\sqrt{2+x}+\sqrt{2-x})}{\cancel{2}x^3}$

$= \lim\limits_{x\to 0} \frac{\sin x(1-\cos^2 x)(\sqrt{2+x}+\sqrt{2-x})}{x^3(1+\cos x)}$ (5)

$= \left(\lim\limits_{x\to 0}\frac{\sin x}{x}\right)^3 \cdot \lim\limits_{x\to 0}\frac{(\sqrt{2+x}+\sqrt{2-x})}{1+\cos x}$ (5)

$= 1^3 \times \frac{2\sqrt{2}}{2}$ (5)

$= \sqrt{2}$.

$\boxed{25}$

4. $\frac{x^2}{a^2}-\frac{y^2}{b^2}=1 \Rightarrow \frac{1}{a^2}2x-\frac{1}{b^2}2y\frac{dy}{dx}=0$ (5)

$\frac{dy}{dx} = \frac{b^2x}{a^2y}$

$\left(\frac{dy}{dx}\right)_{(a\sec\theta,\, b\tan\theta)} = \frac{b^2 a\sec\theta}{a^2 b\tan\theta} = \frac{b}{a\sin\theta}$ (5)

Equation of the normal at P is (5)

$y-b\tan\theta = -\frac{a\sin\theta}{b}(x-a\sec\theta)$

$ax\sin\theta+by = (a^2+b^2)\tan\theta$

$(0,5)$; $\quad 2x\sin\theta+y = 5\tan\theta$

$0+5 = 5\tan\theta$

$\theta = \frac{\pi}{4}$ $[\because 0<\theta<\pi/2]$ (5)

$P \equiv \left(2\sec\frac{\pi}{4}, \tan\frac{\pi}{4}\right)$

$\equiv (2\sqrt{2}, 1)$. (5)

$\boxed{25}$

5. $\tan 2B = \tan((A+B)-(A-B))$

$$= \frac{\tan(A+B) - \tan(A-B)}{1+\tan(A+B)\tan(A-B)} \quad (5)$$

$$= \frac{\frac{1}{2}-\frac{1}{3}}{1+\frac{1}{2}\times\frac{1}{3}} \quad (5)$$

$$= \frac{1}{7}.$$

$\tan 2A = \tan((A+B)+(A-B))$

$$= \frac{\tan(A+B)+\tan(A-B)}{1-\tan(A+B)\tan(A-B)} \quad (5)$$

$$= \frac{\frac{1}{2}+\frac{1}{3}}{1-\frac{1}{2}\times\frac{1}{3}} = 1 \quad (5)$$

$2A = \frac{\pi}{4}$ $\quad [\because 0 < A < \pi/2]$

$A = \frac{\pi}{8}.$ (5) $\quad \boxed{25}$

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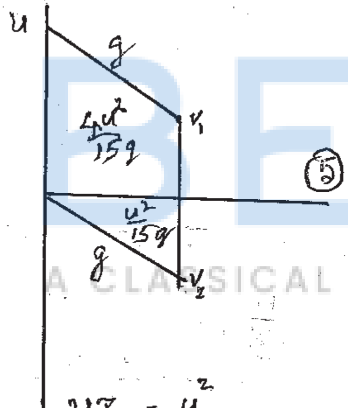


(5) + (5)

$2uT = \frac{u^2}{3g}$

$T = \frac{u}{3g}$ (5)

$V_1 + V_2 = u$

$V_2 = gT = \frac{u}{3}$ (5)

$V_1 = \frac{2u}{3}$ (5) $\quad \boxed{25}$

7. $P \uparrow \quad 0 = V\sin\beta t - \frac{1}{2}gt^2$ (5)

$= \frac{4}{5}Vt - \frac{1}{2}gt^2$

$Q \uparrow \quad 0 = u\sin\alpha \frac{t}{2} - \frac{1}{2}g\frac{t^2}{4}$ (5)

$\Rightarrow \frac{4Vt}{5} = 2u\sin\alpha t$

$u = \frac{2V}{5\sin\alpha}$ (5)

$\rightarrow \frac{2V\sin\beta}{g}, V\cos\beta = \frac{2u\sin\alpha}{g}, \cos\alpha$ (5) (5)

8 $\quad \tan\alpha = \frac{1}{3}$ $\quad \boxed{25}$

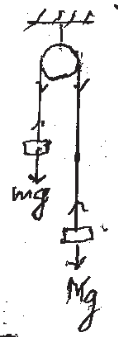
(5)

$T - mg = \frac{mg}{3} \Rightarrow T = \frac{4mg}{3}$ (5)

$Mg - T = \frac{Mg}{3}$ (5)

$\frac{4mg}{3} = \frac{2Mg}{3}$

$M = 2m$ (5)



(5) $\quad \boxed{25}$

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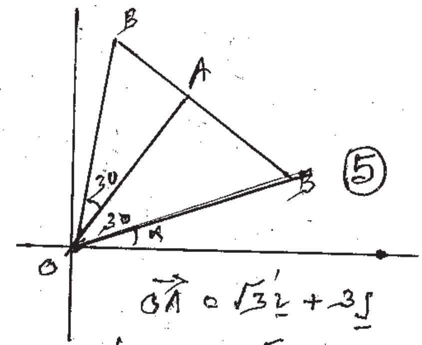

(5)

$\overrightarrow{OA} = \sqrt{3}\,i + 3j$

$\tan(\alpha+30) = \sqrt{3}$

$\alpha = 30$ (5)

$\therefore |\overrightarrow{OA}| = \sqrt{12}$

$|\overrightarrow{OB}| = \sqrt{12}\sec 30^\circ = 4$ (5)

$\therefore \overrightarrow{OB} = 4(\cos 30\, i + \sin 30\, j)$

$= 2\sqrt{3}\, i + 2j$ (5)

or

$\overrightarrow{OB} = 4(\cos 90\, i + \sin 90\, j)$

$= 4j$ (5) $\quad \boxed{25}$

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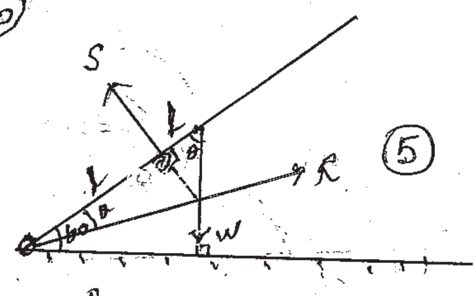


(5)

$60^\circ + \theta = 90^\circ$

$\theta = 30^\circ$ (5)

By Lami's Theorem

$\frac{S}{\sin 120} = \frac{R}{\sin 120} = \frac{W}{\sin 120}$ (5)

$\Rightarrow S = R = W$ (5) + (5)

$\boxed{25}$

∴ the equation whose roots are $|\alpha|, |\beta|$ is $(x-|\alpha|)(x-|\beta|)=0$ (5)

$x^2-(|\alpha|+|\beta|)x+|\alpha||\beta|=0$

$x^2-\sqrt{p^2+4(p-q)}\,x+(p-q)=0$ (5)

$\boxed{40}$

(iii) $(\alpha+1)(\beta+1)$

$=\alpha\beta+(\alpha+\beta)+1$ (5)

$=-(p-q)+p+1$ (5)

$=1+q.$

$\dfrac{(\alpha+1)^2}{(\alpha+1)^2-1-q}+\dfrac{(\beta+1)^2}{(\beta+1)^2-1-q}$

$=\dfrac{(\alpha+1)^2}{(\alpha+1)^2-(\alpha+1)(\beta+1)}+\dfrac{(\beta+1)^2}{(\beta+1)^2-(\alpha+1)(\beta+1)}$ (5)

$=\dfrac{\alpha+1}{\alpha+1-(\beta+1)}+\dfrac{\beta+1}{\beta+1-(\alpha+1)}$

$=\dfrac{\alpha+1}{\alpha-\beta}+\dfrac{\beta+1}{\beta-\alpha}$ (5)

$=\dfrac{\alpha+1-(\beta+1)}{\alpha-\beta}$ (5)

$=1.$

$\boxed{25}$

11.

(a) $x^2-p(x+1)+q=0$

$x^2-px-(p-q)=0$

$\Delta=p^2-4(1)(-)(p-q)$ (5)

$=p^2+4(p-q)>0$ $[\because p>q]$ (5)

∴ the equation has real distinct roots. (5) $\boxed{15}$

(i) $\alpha\beta=-(p-q)<0$ (5)

∴ $\alpha>0$ and $\beta<0$ $[\because \beta<\alpha]$ (5)

$\boxed{10}$

(ii) $\alpha+\beta=p$ (5)

$(|\alpha|+|\beta|)^2$

$=(\alpha-\beta)^2$ $[\because \alpha>0 \text{ and } \beta<0]$ (5)

$=(\alpha+\beta)^2-4\alpha\beta$ (5)

$=p^2+4(p-q)$ (5)

$|\alpha|+|\beta|=\sqrt{p^2+4(p-q)}$ (5)

$|\alpha||\beta|=-\alpha\beta=p-q$ (5)

(b) $p(x)=2x^4+ax^3+bx^2-19x+c$

$p'(x)=8x^3+3ax^2+2bx-19$

$p(x)=(x-1)^2\phi(x)$ (5)

$p'(x)=(x-1)^2\phi'(x)+\phi(x)\,2(x-1)$

$p(1)=0,$ (5) $p'(1)=0$ (5)

$p(1)=0 \Rightarrow 2+a+b-19+c=0$ (5)

$a+b+c=17$ —— (1)

$p'(1)=0 \Rightarrow 8+3a+2b-19=0$ (5)

$3a+2b=11$ —— (2)

$P(-1)=24$ (5)

$\Rightarrow 2-a+b+19+c=24$ (5)

$-a+b+c=3$ —— (3)

$\xRightarrow{(1),(2),(3)}$ $a=7$ (5), $b=-5$ (5), $c=15$ (5)

$\boxed{50}$

$$p(x) = 2x^4+7x^3-5x^2-19x+15$$
$$= (x-1)(2x^3+9x^2+4x-15)$$
$$= (x-1)(x-1)(2x^2+11x+15) \quad (5)$$
$$= (x-1)^2(x+3)(2x+5) \quad (5)$$
$\boxed{10}$

12.

(a) $f(x) = \dfrac{x(x+1)}{(x-1)^2}$

$$f'(x) = \frac{(x-1)^2(2x+1)-(x^2+x)2(x-1)}{(x-1)^4} \quad (20)$$
$$= \frac{(x-1)(2x+1)-2(x^2+x)}{(x-1)^3}$$
$$= \frac{2x^2-x-1-2x^2-2x}{(x-1)^3}$$
$$= -\frac{3x+1}{(x-1)^3} \quad (5)$$
$\boxed{25}$

$f'(x) = 0 \iff x = -\frac{1}{3}$ (5)

	$-\infty < x < -\frac{1}{3}$	$-\frac{1}{3} < x < 1$	$1 < x < \infty$
sign of $f'(x)$	$(-)$	$(+)$	$(-)$
$f(x)$ is	decreasing	increasing	decreasing
	(5)	(5)	(5)

$f(x)$ is increasing on $[-\frac{1}{3}, 1)$, and decreasing on $(-\infty, -\frac{1}{3}]$ and $(1, \infty)$. (5)

Turning point : $(-\frac{1}{3}, -\frac{1}{8})$ is a local minimum. (5)

$f''(x) = 0 \iff x = -1$ (5)

	$-\infty < x < -1$	$-1 < x < 1$	$1 < x < \infty$
sign of $f''(x)$	$(-)$	$(+)$	$(+)$
concavity	concave down	concave up	concave up
	(5)	(5)	

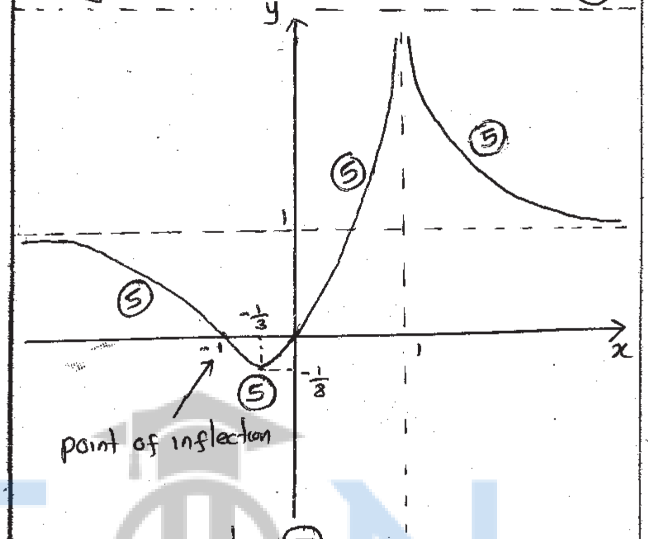
$(-1, 0)$ is a point of inflection (5)

$\lim\limits_{x \to 1} \dfrac{x(x+1)}{(x-1)^2} = \infty$

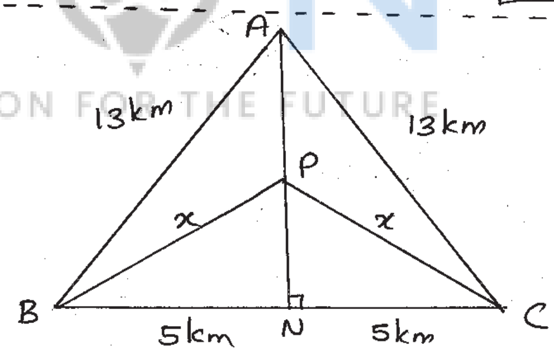
$\therefore x = 1$ is a vertical asymptote (5)

$\lim\limits_{x \to \pm\infty} \dfrac{x(x+1)}{(x-1)^2} = \lim\limits_{x \to \pm\infty} \dfrac{1+\frac{1}{x}}{(1-\frac{1}{x})^2} = 1$ $\boxed{60}$

$\therefore y = 1$ is a horizontal asymptote (5)



$k_{max} = -\frac{1}{3}$ (5) $\boxed{25}$



$PN = \sqrt{x^2-25}$ (5)

$$L(x) = AP + BP + CP$$
$$= 12 - \sqrt{x^2-25} + 2x \quad (5)$$
$$= 2x + 12 - \sqrt{x^2-25}$$
$$L'(x) = 2 - \frac{1}{2\sqrt{x^2-25}}(2x) \quad (10)$$
$$= \frac{2\sqrt{x^2-25} - x}{\sqrt{x^2-25}}$$

$$L'(x) = \frac{4(x^2-25) - x^2}{(2\sqrt{x^2-25}+x)(\sqrt{x^2-25})}$$

$$= \frac{3\left(x^2 - \frac{100}{3}\right)}{(2\sqrt{x^2-25}+x)\sqrt{x^2-25}} \quad (5)$$

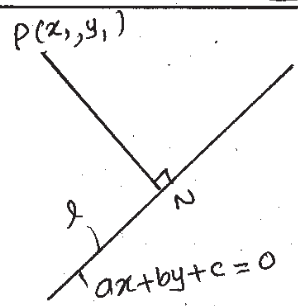
$L'(x) = 0 \iff x = \frac{10}{\sqrt{3}}$ (5)

For $5 < x < \frac{10}{\sqrt{3}}$, $L'(x) < 0$ (5) and for $\frac{10}{\sqrt{3}} < x < 13$, $L'(x) > 0$ (5)

$\therefore$ $L(x)$ is minimum when $x = \frac{10}{\sqrt{3}}$ km (5)

$\boxed{45}$

13.



Equation of the line PN is

$y - y_1 = \frac{b}{a}(x - x_1)$

$\frac{y-y_1}{b} = \frac{x-x_1}{a} = t$ (say) (5)

$x = x_1 + at,\ y_1 = y_1 + bt$ $\boxed{10}$

$(x_1+at,\ y_1+bt)$ (5)

Since N lies on $l = 0$

$a(x_1+at) + b(y_1+bt) + c = 0$ (5)

$t = -\frac{ax_1+by_1+c}{a^2+b^2}$ (5)

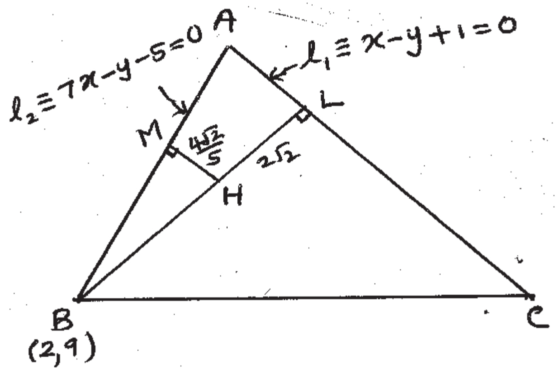
$PN = \sqrt{a^2t^2 + b^2t^2}$ (5)

$= \sqrt{a^2+b^2}\,|t|$ (5)

$= \sqrt{a^2+b^2}\,\frac{|ax_1+by_1+c|}{a^2+b^2}$ (5)

$= \frac{|ax_1+by_1+c|}{\sqrt{a^2+b^2}}$ (5)

$\boxed{30}$



(i) $x - y + 1 = 0$ — (1)

$7x - y - 5 = 0$ — (2)

(2)−(1) $\Rightarrow$ $6x - 6 = 0$

$x = 1$

$y = 2$

$A \equiv (1, 2)$ (10) $\boxed{10}$

(ii) $7x - y - 5 = 0$, $(1, 2)$ (10)

$L.H.S = 7(1) - 2 - 5 = 0 = R.H.S$

$\therefore$ the point $B(2, 9)$ lies on $7x - y - 5 = 0$ $\boxed{10}$

(iii) $H \equiv (2+t,\ 9-t)$ (5)

$HL = 2\sqrt{2}$

$\frac{|(2+t) - (9-t) + 1|}{\sqrt{2}} = 2\sqrt{2}$ (10) (5)

$|t - 3| = 2$ (5)

$t - 3 = \pm 2$

$t = 5$ or $t = 1$ (5) — (1)

$HM = \frac{4\sqrt{2}}{5}$

$\frac{|7(2+t) - (9-t) - 5|}{5\sqrt{2}} = \frac{4\sqrt{2}}{5}$ (10) (5)

$|t| = 1$ (5)

$t = \pm 1$ (5) — (2)

(1), (2) $\Rightarrow$ $t = 1$ (5)

$H \equiv (3, 8)$ (5) $\boxed{65}$

(iv) Equation of the straight line through H, perpendicular to l_2 is

$y - 8 = -\frac{1}{7}(x - 3)$ (5)

$x + 7y - 59 = 0$

$$\left.\begin{aligned} x+7y-59&=0 \\ x-y+1&=0 \end{aligned}\right\} \quad C \equiv \left(\frac{13}{2}, \frac{15}{2}\right)$$ (10) [15]

Equation of BC is

$$y-9 = \frac{\frac{15}{2}-9}{\frac{13}{2}-2}(x-2)$$ (5)

$$x+3y-29=0$$ (5)

[10]

14.

(a) $\sin(A+B) = \sin A\cos B + \cos A \sin B$ (5) [5]

$\cos(A-B)$

$= \sin\left(\frac{\pi}{2}-(A-B)\right)$

$= \sin\left[\left(\frac{\pi}{2}-A\right)+B\right]$

$= \sin\left(\frac{\pi}{2}-A\right)\cos B + \cos\left(\frac{\pi}{2}-A\right)\sin B$ (5)

$= \cos A\cos B + \sin A \sin B$ (5)

[10]

(i) $k>2$

$f(x) = k\sin\left(x+\frac{\pi}{4}\right) - 2\cos\left(x-\frac{\pi}{4}\right)$

$= k\sin\left(x+\frac{\pi}{4}\right) - 2\sin\left(\frac{\pi}{2}+\left(x-\frac{\pi}{4}\right)\right)$ (5)

$= k\sin\left(x+\frac{\pi}{4}\right) - 2\sin\left(x+\frac{\pi}{4}\right)$

$= (k-2)\sin\left(x+\frac{\pi}{4}\right)$ (5)

$= p\sin(x+\alpha)$; $p=k-2$ (5)

$\alpha = \pi/4$ [15]

(ii) $k<2$

$f(x) = (k-2)\sin\left(x+\frac{\pi}{4}\right)$

$= (2-k)\sin\left(\pi+\left(x+\frac{\pi}{4}\right)\right)$ (5)

$= (2-k)\sin\left(x+\frac{5\pi}{4}\right)$ (5)

$= q\sin(x+\beta)$; $q = 2-k$ (5)

$\beta = \frac{5\pi}{4}$ [15]

$f(x) = |k-2|$

case (i) $k>2$

$(k-2)\sin\left(x+\frac{\pi}{4}\right) = k-2$ (5)

$\sin\left(x+\frac{\pi}{4}\right) = 1 = \sin\pi/2$ (5)

$x+\frac{\pi}{4} = n\pi + (-1)^n\frac{\pi}{2}$, $n\in\mathbb{Z}$

$x = n\pi + (-1)^n\frac{\pi}{2} - \frac{\pi}{4}$, $n\in\mathbb{Z}$ (5)

case (ii) $x<2$

$(2-k)\sin\left(x+\frac{5\pi}{4}\right) = 2-k$ (5)

$\sin\left(x+\frac{5\pi}{4}\right) = 1 = \sin\frac{\pi}{2}$ (5)

$x+\frac{5\pi}{4} = n\pi + (-1)^n\pi/2$, $n\in\mathbb{Z}$

$x = n\pi + (-1)^n\frac{\pi}{2} - \frac{5\pi}{4}$, $n\in\mathbb{Z}$ (5)

[30]

(b) $A+B+C = \pi$

$A+B = \pi - C$

$\tan(A+B) = \tan(\pi-C) = -\tan C$ (5)

$\frac{\tan A+\tan B}{1-\tan A\tan B} = -\tan C$ (5)

$\tan A+\tan B = -\tan C + \tan A\tan B\tan C$ (5)

$\frac{\tan A+\tan B+\tan C}{\tan A\tan B\tan C} = 1$

$\cot A\cot B + \cot B\cot C + \cot C\cot A = 1$ (5)

[20]

$\cot A + \cot B + \cot C = \sqrt{3}$

$(\cot A+\cot B+\cot C)^2 = 3$ (5)

$\cot^2A + \cot^2B + \cot^2C + 2\cot A\cot B$

$+ 2\cot B\cot C + 2\cot C\cot A = 3$ (5)

$\cot^2A + \cot^2B + \cot^2C + 2(1) = 3$ (5)

$\cot^2A + \cot^2B + \cot^2C = 1$ [15]

$\left(\cot A - \frac{1}{\sqrt{3}}\right)^2 + \left(\cot B - \frac{1}{\sqrt{3}}\right)^2 + \left(\cot C - \frac{1}{\sqrt{3}}\right)^2$ (5)

$= \cot^2A + \cot^2B + \cot^2C - \frac{2}{\sqrt{3}}(\cot A+\cot B+\cot C)$ (5)

$+\frac{1}{3}+\frac{1}{3}+\frac{1}{3}$

$= 1 - \frac{2}{\sqrt{3}}(\sqrt{3}) + 1$

$= 0$ (5)

$\therefore \cot A = \frac{1}{\sqrt{3}}$, $\cot B = \frac{1}{\sqrt{3}}$, $\cot C = \frac{1}{\sqrt{3}}$ (5)

$A = B = C = \pi/3$

$\therefore \Delta ABC$ is an equilateral triangle.

[20]

(c)

$\sin^{-1}(2-x) - 2\sin^{-1}(x-1) = \frac{\pi}{2}$

Let $\alpha = \sin^{-1}(2-x)$, $\beta = \sin^{-1}(x-1)$

$\alpha - 2\beta = \frac{\pi}{2}$

$\alpha = \frac{\pi}{2} + 2\beta$

$\sin\alpha = \sin(\pi/2 + 2\beta)$

$\sin\alpha = \cos 2\beta$ (5)

$\sin\alpha = 1 - 2\sin^2\beta$

$2 - x = 1 - 2(x-1)^2$ (5)

$2x^2 - 5x + 3 = 0$

$(x-1)(2x-3) = 0$

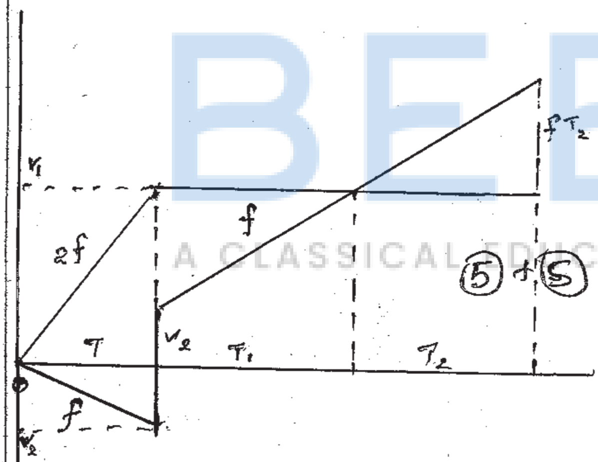
$x = 1$ or $x = 3/2$ (5)

$x = \frac{3}{2}$ does not satisfy the eq^n

$\therefore x = 1$ (5)

$\boxed{20}$

15 a)



(5) + (5)

I $v_1 = 2fT$ (5)
$v_2 = fT$ (5)

$v_1 - v_2 = fT_1$
$fT = fT_1$ (5)
$T_1 = T$ (5)

II Time taken to equal velocity is $2T$. (5)

III $\frac{1}{2}(T + 2T_1 + 2T_2)v_1 = \frac{1}{2}(v_2 + v_1 + fT_2) - \frac{1}{2}fT_1T$

(5) + (5) + (5)

$T_2 = 2T$ (5)

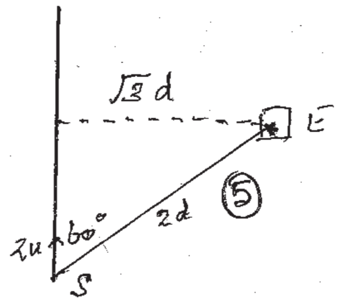
time is $T + T_1 + T_2 = 4T$ (5)

IV Speed of B $= v_1 + fT_2$ (5)
$= 4fT$ (5)

$\boxed{70}$

b)

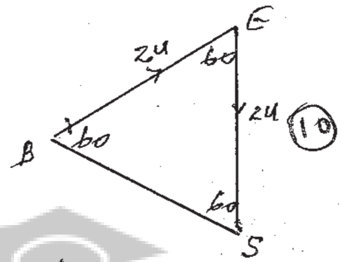
I



II $2d = v.\frac{d}{u}$
$v = 2u$ (5)

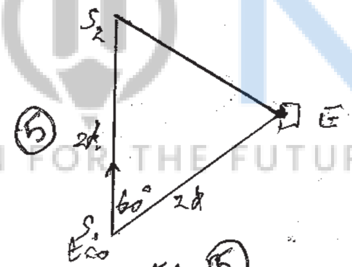
III $V_{BS} = V_{BE} + V_{ES}$

IV $\overset{60°}{\nearrow} 2u$ $\uparrow 2u$ (5)



$V_{BS} = 2u$ (5) $\overset{60}{\searrow} 2u$ (5)

IV

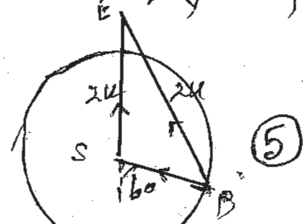


V_{BS} $\overset{60}{\searrow}$ (5) V_{BE} $\uparrow 2u$

V_{BE} 2u

$V_{BE} = V_{BS} + V_{SE}$ (5)

2u $\overset{60}{\searrow}$ + $\uparrow 2u$



in triangle SBE

$SE = BE = 2u$

$\Rightarrow E\hat{S}B$ must acute angle. (5)

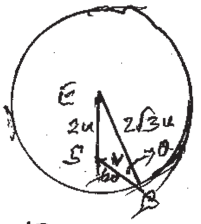
But in the figure $E\hat{S}B = 120°$

$\Rightarrow$ This is impossible to reach the ship

(v) V_{BS} ↙ $\quad V_{BE}$ $2\sqrt{3}u$

$V_{BS} = V_{BE} + V_{ES}$

v ↙ $\quad 2\sqrt{3}u \quad \downarrow 2u$



(10)

$\frac{2u}{\sin\theta} = \frac{2\sqrt{3}u}{\sin(\pi - 60)} = \frac{v}{\sin(60-\theta)}$

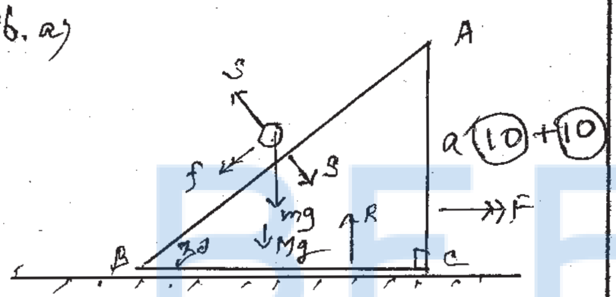
$\sin\theta = \frac{1}{2} \Rightarrow \theta = 30^\circ$

$v = 2u$ (5)

$T = \frac{2d}{2u} = \frac{d}{u}$ (5)

$\boxed{80}$

16. a)



a (10)+(10)

$AB = a \operatorname{cosec} 30^\circ = 2a$

I P related to wedge $s = ut + \frac{1}{2}at^2$

$2a = \frac{1}{2} f \frac{6a}{g}$ (5)

$f = \frac{2g}{3}$ (5)

II for P $F = ma$

↙ $mg\sin 30 = m(f - F\cos 30)$ (10)

$F = \frac{g}{3\sqrt{3}}$ (5)

III for the system →

$0 = MF + m(F - f\cos 30)$ (10)

$M = 2m$ (5)

IV ↑ $R - 3mg = 2m \cdot 0 + m(-f\sin 30)$ (10)

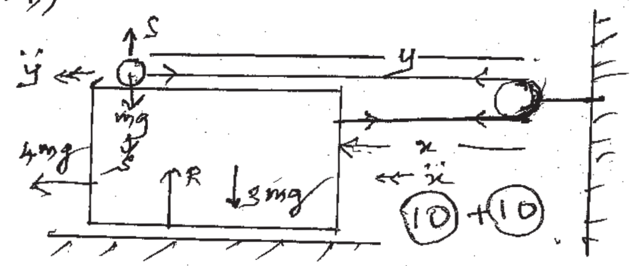
$R = \frac{8mg}{3}$ (5)

V ↖ $S - mg\cos 30 = m(-F\sin 30)$ (10)

$S = \frac{4mg}{3\sqrt{3}}$ (5)

$\boxed{90}$

b)



(10)+(10)

$x + y = c$

$\ddot{x} + \ddot{y} = 0$ (5)

for P $\quad -T = m\ddot{y}$ (5)

for System ←

$4mg - 2T = 3m\ddot{x} + m\ddot{y}$ (10)

$\ddot{x} = g$ (5)

for P, related to wedge

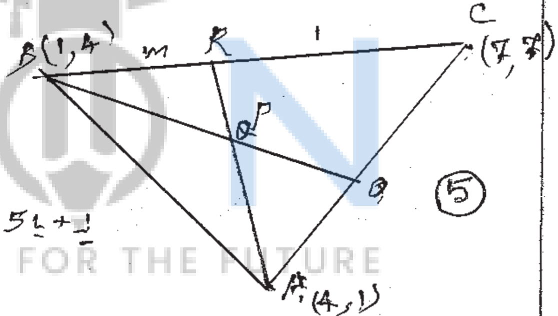
→ $s = ut + \frac{1}{2}at^2$

$2a = \frac{1}{2}(2\ddot{x}) \cdot t^2$ (5)+(5)

$t = \sqrt{\frac{2a}{g}}$ (5)

$\boxed{60}$

17 a)



(5)

$\vec{BQ} = 5i + j$

$\vec{AB} = -3i + 3j$ (5)

$\vec{AC} = 3i + 6j$ (5)

$\vec{AR} = \vec{AB} + \vec{BR}$ (5)

$= -3i + 3j + \frac{m}{m+1}\vec{BC}$

$= -3i + 3j + \frac{m}{m+1}(6i + 3j)$ (5)

$= [(3m-3)i + (6m+3)j]\frac{1}{m+1}$

$AR \perp BC \Rightarrow \vec{AR} \cdot \vec{BC} = 0$ (5)

$\frac{(3m-3)i + (6m+3)j}{m+1} \cdot (6i + 3j) = 0$ (5)

$6(3m-3) + 3(6m+3) = 0$

$m = \frac{1}{4}$ (5)

$\vec{AR} = \frac{-9i + 18j}{5}$

$\vec{AR}\cdot\vec{BQ} = AR\cdot BQ\cos\theta$ (5)

$\left(\frac{-9i+18j}{5}\right)\cdot(5i+j) = \frac{9\sqrt{5}}{5}\cdot\sqrt{26}\cos\theta$ (5) (5)

$-9+\frac{18}{5} = \frac{9\sqrt{5}}{5}\cdot\sqrt{26}\cos\theta$

$27 = 9\sqrt{130}\cos\theta$

$\theta = \cos^{-1}\left(\frac{3}{\sqrt{130}}\right)$ (5)

$\vec{BQ} = \lambda\vec{BA} + \mu\vec{BC}$

$5i+j = \lambda(3i-3j)+\mu(6i+3j)$ (5)

$(5-3\lambda-6\mu)i + (1+3\lambda-3\mu)j = 0$

$5-3\lambda-6\mu = 0$

$1+3\lambda-3\mu = 0$

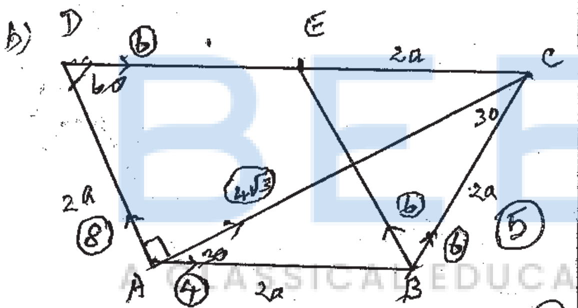
$6-9\mu = 0$

$\mu = \frac{2}{3}$ (5)

$\lambda = \frac{1}{3}$ (5)

$\boxed{75}$

b)



I

$\rightarrow x = 4+6+6\cos60 - 6\cos60 - 8\cos60 + 4\sqrt{3}\cos30$ (5)

$= 12$ (5)

$\uparrow y = 8\sin60 + 4\sqrt{3}\sin30 + 12\sin60$ (5)

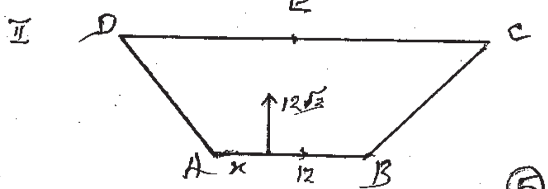
$= 12\sqrt{3}$ (5)

$R = 24$ (5)

$\tan\theta = \sqrt{3}$

$\theta = 60^\circ$ (5)

II

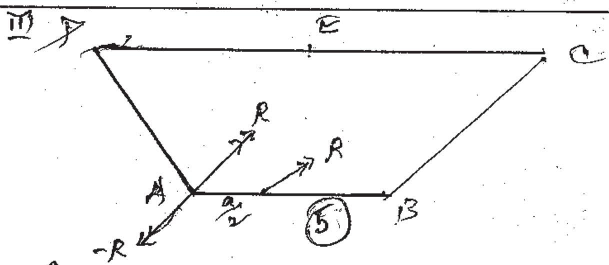


(5)+(5)

A↻ $12\sqrt{3}x = 6\cdot 2a\cos30 + 6\cdot 2a\cos30 - 6\cdot 2a\cos30$

$x = \frac{a}{2}$ (5)

III

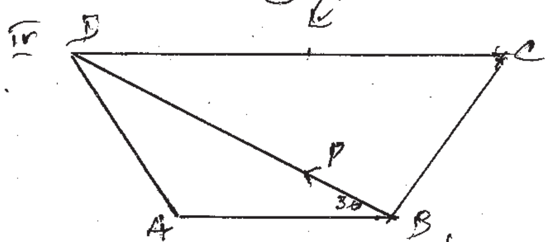


A↻ $G = \frac{a}{2}\cdot 12\sqrt{3}$ (5)

$= 6\sqrt{3}a$

$R = 24$ (5) 15

IV



New Resultant is perpendicular

$\Rightarrow P\cos30 - 12 = 0$ (5)

$P = 8\sqrt{3}$ (5)

$\boxed{75}$