Ε			_	-	_				
8		_		rcise		_			
<u>.</u>	1	В	2.	D	3	С			
ğ	4.	4.8 Ma		<b>5.</b>	$1/\sqrt{2}$	_			
$\frac{1}{2}$	6.	В	7.	D	8.	D			
Ś	9.	A	10. 13.	С	11. 14.	C			
$\mathcal{L}$	15.	C	13. 16.	D	1 <del>4</del> . 17.	C			
S	18.	Č	19.	D	<b>20.</b> B	Ŭ			
ŧ	21.	AC	22.	D	23.	D			
Š	24.	С	25.	A	26.	D			
≥.	27. 20	C	28. 31.	B D	29. 32.	C			
≶	30. 33.	A D C C AC C C C A	31. 34.	D	35.				
≶	36.	A	<b>37.</b>		38.				
∞	39.	В	40.	D	41.	Α			
Ε	<b>42</b> .	В	43	D					
Ö		Exercise - 2							
 O	SECTION (A) :								
ő	A 1.	20 s							
SS	A 2.	(a) <w< td=""><td>&gt; = 2a /</td><td>3 = 4  rad</td><td>d/s;</td><td></td></w<>	> = 2a /	3 = 4  rad	d/s;				
<u>a</u>		$<\beta> = \sqrt{3ab} = 6 \text{ rad/s}^2;$							
Exercise - 1  B 2. D 3.  4. 4.8 Ma² 5. $1/$ 6. B 7. D 8.  9. A 10. 11.  15. C 16. D 17.  18. C 19. D 20.  18. C 22. D 23.  24. C 25. A 26.  27. C 28. B 29.  30. C 31. D 32.  33. A 34. D 35.  36. A 37. 38.  39. B 40. D 41.  42. B 43 D  Exercise - 2  SECTION (A):  A 1. 20 s  A 2. (a) $<$ w> = $2a/3$ = $4$ rad/s; $<$ b> = $$ section (B):  (b) $\beta$ = $2\sqrt{3}$ ab = $12$ rad /s².  (b) $\beta$ = $2\sqrt{3}$ ab = $12$ rad /s².  (c) $\beta$ = $\sqrt{3}$ ab = $12$ rad /s².  B 1. (i) $I = \frac{a\ell^4}{4}$ (ii) $\frac{a\ell^4}{36}$ B 2. $1.5 \times 10^{-3}$ kg·m³, $4.0 \times 10^{-3}$ B 3. $\frac{100}{1000}$ ( $1^2 + 2^2 + 3^2 + \dots$ ) ×  B 4. $\frac{MR^2}{2} - M\left(\frac{4R}{3\pi}\right)^2$ B 5  B 5. $\frac{14 \text{ mr}^2}{5}$ B 6. $\frac{14 \text{ mr}^2}{5}$ B 7. $\sqrt{\frac{1}{m}}\left(I - \frac{m\ell^2}{12}\right) = \sqrt{\frac{7}{60}} = 0$ .  B 8 8. (a) $I = (1/2) \pi \rho b R^4 = 2.8 \text{ g.m²}$ B 9. $I = m (a^2 + b^2)$ ] B 11. $\sqrt{2}$ r B 12.  B 13. $\frac{2\rho a^7}{21}$ B 14. $\frac{m\ell}{6}$									
<u>\$</u>	A 3.	$t = \sqrt[3]{(4/a)\tan\alpha} = 7 s$							
ζ.		. 1	,, carre						
≶	SECTIO	N (B) :							
≶		` ′			. /				
 Ф	B 1.	(i) I =	$\frac{a\ell^4}{4}$	(ii) $\frac{a\ell^2}{36}$	-				
Sit	B 2.	1.5 ×	10 <sup>–₃</sup> kg-ı	m³, 4.0 ×	: 10 <sup>–</sup> 3 kg	-m			
/ek	В 3.	$\frac{100}{1000}$	$1^2 + 2^2 -$	+32 +	)×10	-6 <u>-</u>			
≥		1000							
$\Xi$			L						
ţ	D 4	$MR^2$	$-M\left(\frac{4}{3}\right)$	$ R ^2$	D. 5	N			
<u>0</u>	В 4.	2	- M ( 3	$\frac{\overline{3\pi}}{2}$	B 5.	_			
ag									
X	D 6	14 mr	2						
ğ	ь о.	5	_						
$\overline{\Gamma}$									
र्व	_	1 (,	$m\ell^2$	$= \sqrt{\frac{7}{60}}$					
it	B 7.	$\sqrt{m}$	12	$=\sqrt{60}$	= 0.34	m			
<u>S</u>	ВО	(0) =	(1/0)	hD4 0.0	) er ma 21				
ao	B8. RQ	(a) ⊥ =	(1/2) πρ (2² ± b²\1	bR <sup>4</sup> = 2.8	s g.m²] <b>B 10.</b>	m			
0	B 11.		(α + υ )]		B 12.	r/			
Ž	<b>-</b>					1/			
ò	B 13.	$2\rho a^7$		B 14.	$m\ell^2$				
	וט.	21		J 14.	6				
Щ			(124	B <sub>2</sub> 5)					
ZE	B 15.	(a) 2π	$\left(\frac{Aa^4}{4} + \right)$	<u>5</u>					
芷		` '	( +	3 )					

15.	С	16.	D	17.	С
18.	С	19.	D	<b>20.</b> B	
21. 24.	AC	22.	D	23.	D
24	C	25	Α	26	D

## SECTION (A):

- A 1.
- A 2. (a) < w > = 2a / 3 = 4 rad/s;

$$<\beta> = \sqrt{3ab} = 6 \text{ rad/s}^2;$$

(b) 
$$\beta = 2\sqrt{3ab} = 12 \text{ rad /s}^2$$
.

## SECTION (B):

**B 1.** (i) 
$$I = \frac{a\ell^4}{4}$$
 (ii)  $\frac{a\ell^4}{36}$ 

**B 2.** 
$$1.5 \times 10^{-3} \text{ kg-m}^3, 4.0 \times 10^{-3} \text{ kg-m}^3$$

**B 3.** 
$$\frac{100}{1000} (1^2 + 2^2 + 3^2 + \dots) \times 10^{-6} = 0.43 \text{ kg-m}^2$$

**B 4.** 
$$\frac{MR^2}{2} - M\left(\frac{4R}{3\pi}\right)^2$$
 **B 5.**  $\frac{M\ell^2}{3}$ 

**B 6.** 
$$\frac{14 \text{ mr}^2}{5}$$

**B 7.** 
$$\sqrt{\frac{1}{m}} \left( I - \frac{m\ell^2}{12} \right) = \sqrt{\frac{7}{60}} = 0.34 \text{ m}$$

**B 8.** (a) 
$$I = (1/2) \pi \rho b R^4 = 2.8 \text{ g.m}^2$$

**B 8.** (a) 
$$I = (1/2) \pi \rho b R^4 = 2.8 \text{ g.m}^2$$
]  
**B 9.**  $I = m (a^2 + b^2)$ ] **B 10.**  $ma^2/$ 

**B 11.** 
$$\sqrt{2}$$
 r

**B 12.** 
$$r/\sqrt{2}$$

**B 13.** 
$$\frac{2\rho a^7}{21}$$
 **B 14.**  $\frac{m\ell^2}{6}$ 

**B 15.** (a) 
$$2\pi \left( \frac{Aa^4}{4} + \frac{Ba^5}{5} \right)$$

(b)  $I = 3/10 \text{ mR}^2$ B 16.

#### SECTION (C):

N = (aB - bA)k, where k is the unit vector of

the z axis 
$$\ell = |aB - bA|/\sqrt{A^2 + B^2}$$

**C 2.** 
$$\ell = |aB - bA| / \sqrt{A^2 + B^2}$$

C 3. 
$$v_2 = v_1 \frac{r_1 \rho_1 \eta_2}{r_2 \rho_2 \eta_1} = 5 \mu m/s$$

#### SECTION (D):

**D 1.** 
$$P = \frac{W}{2} \cot \theta \text{ or } P = \frac{mg}{2} \cot \theta$$

**D 2.** 76 g, 42 g, 
$$\frac{21}{38}$$
.

- 1.04 N in the left string and 1.12 N in the right D 3.
- D 4.
- D 5.

D 6. 
$$\frac{L\cos\theta\sin^2\theta}{2h-L\cos^2\theta\sin\theta}$$
 D 7. 
$$\frac{3W}{8}$$

#### SECTION (E):

E 1.

**E 2.** (a) 
$$\frac{2g(m_1 - m_2)}{\ell(m_1 + m_2)} = \frac{60}{7} = 8.4 \text{ rad/s}^2$$

1.04 N in the left string and 1.12 N in the right 1.24 N (a) T = 225 N (b) F<sub>x</sub> = 225 N, F<sub>y</sub> = 300 N (b) F<sub>x</sub> = 225 N, F<sub>y</sub> = 300 N (c) 
$$\frac{L\cos\theta\sin^2\theta}{2h - L\cos^2\theta\sin\theta}$$
 D7.  $\frac{3W}{8}$  O: and  $\frac{2g(m_1 - m_2)}{\ell(m_1 + m_2)} = \frac{60}{7} = 8.4 \text{ rad/s}^2$  (b) (i)  $\frac{2g(m_1 - m_2)}{\ell(m_1 + m_2 + m_3/3)} = \frac{90}{22} = 8.0 \text{ rad/s}^2$ ,  $\frac{2}{3}$  (ii)  $\frac{2g(m_1 - m_2)}{\ell(m_1 + m_2 + m_3/3)} = \frac{90}{22} = 8.0 \text{ rad/s}^2$ ,  $\frac{2}{3}$  (ii)  $\frac{3g}{4L}$  (cw) (b)  $\frac{13mg}{16}$   $\frac{1}{3}$  (cw)  $\frac{3g}{4L}$  (cw) (b)  $\frac{13mg}{16}$   $\frac{1}{3}$  Substituting the string and 1.12 N in the right 1.22 N in th

(ii) 
$$(m_1 g - m_1 \alpha \frac{\ell}{2}) = 29 N$$
;

$$(m_2 g + m_2 \alpha \frac{\ell}{2}) = 27.6 \text{ N}$$

**E 3.** (a) 
$$\frac{3g}{4L}$$
 (cw) (b)  $N = \frac{13mg}{16}$ 

$$F = \left(\frac{3\sqrt{3}}{16}\right) \text{ mg} \rightarrow \text{(c) } \frac{3\sqrt{3}}{13}$$

**E 4.** (a) 
$$\frac{3g}{2\sqrt{2}\ell}$$
 (cw) (b)  $\frac{3}{2}g \downarrow$  (c)  $\frac{Mg}{4}\uparrow$ 

**E 5.** (a) 
$$\frac{g}{7}$$
 m/s<sup>2</sup> (b) 0.125 m/s<sup>2</sup>

**E 6.** (a) 
$$\frac{g}{11}$$
 (b)  $\frac{20g}{31}$  N

E7. 
$$T = 1/2mg$$
,  $a = gmr^2/I$ 

bage '

**E 11.** 
$$x = \frac{2L}{3}$$

**E 12.** 
$$\frac{M}{m} = \sqrt{15}$$

## SECTION (F):

**F 1.** 
$$\sqrt{\frac{3g}{\ell}} = 5.4 \text{ rad/s}$$

**F 2.** 
$$w = \sqrt{5} \text{ rad/}$$

**F 3.** 
$$\frac{1}{19}\sqrt{380g}$$

**F 4.** 
$$\omega = \sqrt{\frac{9g}{4\ell}}$$

F 6. 
$$\alpha$$

$$\frac{3\mathsf{gcos}\theta}{2\ell}$$

## SECTION (G):

**G 1.** 
$$0.9\sqrt{2}$$
 dmg

**G 2.** (a) T = 2mg (b) N = 6mg (c) 
$$\frac{3g}{5L}$$
 (d)  $\sqrt{\frac{6g}{5L}}$ 

## SECTION (H)

**H 2.** 
$$2\hat{k} \text{ kg m}^2/\text{s}$$

**H 3.** 
$$0.5 \text{ kg-m}^2/\text{s}, 75 \text{ J}$$

**H 8.** 
$$\omega = \frac{45}{14} = 3.21 \text{ rad/s (ccw)}, v_s = \frac{1}{7} 0.143 \text{ m/s}$$

H 9. 
$$\frac{4\pi m}{M+2m}$$

**H 12.** (a) 
$$\omega = \frac{12V}{7L}$$
 (b)  $v = \frac{7}{12}\sqrt{2gL} = 3.5 \text{ m/s}$ 

# SECTION (I):

I 1. (a) 
$$\frac{4v_0}{3}$$
 (b)  $\frac{5v_0}{3\ell}$  (c)  $v_x = \frac{v_0}{2}$ ,  $v_y = \frac{2v_0}{3}$ 

E9. 
$$\tau = 3/4 \, \omega R/kg$$
. E10.  $<\omega > = 1/3 \, w_o$ 

E11.  $x = \frac{2L}{3}$ 

E12.  $\frac{M}{m} = \sqrt{15}$ 

SECTION (F):

F1.  $\sqrt{\frac{3g}{\ell}} = 5.4 \, \text{rad/s}$ 

F2.  $w = \sqrt{5} \, \text{rad/s}$ 

SECTION (G):

F3.  $\frac{1}{19} \sqrt{380g}$ 

F4.  $\omega = \sqrt{\frac{9g}{4\ell}}$ 

F5. 0.5 m/s

F6.  $\alpha = \frac{3g\cos\theta}{2\ell}$ 

SECTION (G):

G1. 0.9 $\sqrt{2}$  dmg

G2. (a)  $T = 2mg$  (b)  $N = 6mg$  (c)  $\frac{3g}{5L}$  (d)  $\sqrt{\frac{6g}{5L}}$ 

SECTION (H):

H1. 16 kg m²/s

H3. 0.5 kg-m²/s, 75 J

H4. 19.7 rad/s

H6. 0.04 kg-m²

H7. 12 rad/s

H8.  $\omega = \frac{45}{14} = 3.21 \, \text{rad/s}$  (ccw),  $v_s = \frac{1}{7} \, 0.143 \, \text{m/s}$ 
 $\omega = \frac{4\pi m}{M+2m}$ 

H10. 6.3 m/s

H11. 41°

H12. (a)  $\omega = \frac{12V}{7L}$  (b)  $v = \frac{7}{12} \sqrt{2gL} = 3.5 \, \text{m/s}$ 

H13. 0.8 rev/s

SECTION (I):

(a)  $\frac{4v_0}{3}$  (b)  $\frac{5v_0}{3\ell}$  (c)  $v_x = \frac{v_0}{2}$ ,  $v_y = \frac{2v_0}{3}$ 

12. (a)  $w_A = v^2 / R = 2.0 \, \text{m/s}^2$ , the vector  $w_A$  is permanently directed to the centre of the wheel is (b)  $s = 8R = 4.0 \, \text{m}$ ]

13.  $\frac{7}{10} \, \text{mv}^2$ 

H14. (a)  $v_A = 2\omega t = 10.0 \, \text{cm/s}$ ,

I 3. 
$$\frac{7}{10}$$
 mv<sup>2</sup>

I 4. (a) 
$$v_A = 2\omega t = 10.0 \text{ cm/s},$$
  
 $v_B = \sqrt{2} \omega t = 7.1 \text{ cm/s}, v_B = 0;$ 

(b) 
$$\omega_A = 2\omega \sqrt{1 + (\omega t^2/2R)^2} = 5.6 \text{ cm/s}^2$$
,

$$\omega_{\rm B} = \omega \sqrt{1 + (1 - \omega t^2/R)^2} = 2.5 \text{ cm/s}^2,$$

$$\omega_0 = \omega^2 t^2 / R = 2.5 \text{ cm/s}^2$$

I 5. 
$$R_{\Delta} = 4r$$
,

$$R_B = 2\sqrt{2} r$$

#### SECTION (J):

(b) 
$$\alpha$$
 = 4.00 rad/s² (ccw) ;  $\overline{a}\,$  = 1.800 m/s²  $\rightarrow$ 

**J 3.** 
$$\frac{\omega \ell}{6}$$
 m/s,  $\frac{\ell}{6}$  m below the centre of the rod

**J 4.** 
$$\sqrt{10gh/7}$$

**J 5.** 
$$\frac{3v^2}{4g}$$

**J 6.** 
$$\sqrt{\frac{10}{7}} g \ell \sin \theta$$

**J 8.** 
$$v = \sqrt{\frac{14 \, \text{g R}}{3}}$$

**J 10.** (a) 
$$T = w$$
 (b)  $\alpha = rg/k^2$  (ccw)

**J 11.** 
$$\frac{2}{3}$$
g **J 12.** (a)  $\frac{2}{5}$ tanθ (b)  $\frac{7}{8}$  mglsinθ

**J 13.** 3.3 N **J 14.** 
$$\frac{25}{9}$$
 m/s  $\leftarrow$ 

J 15. 
$$\ell = 2aF_2/mw = 1.0$$

(b) 
$$\left(\frac{\sqrt{3}}{2}\hat{i} + \hat{j}\right) g = 1.323 g \angle 49.1^{\circ}$$

$$(c)\left(\frac{\sqrt{3}}{2}\hat{i}-2\hat{j}\right) g = 2.18g \angle -66.6^{\circ}$$

(ii) (a) g/L (cw) (b) 
$$-\left(\frac{\sqrt{3}}{2}\right)$$
 g  $\hat{i}$ 

(c) 
$$-\left(\frac{\sqrt{3}}{2}\hat{i} + \hat{j}\right) g = 1.323 g \angle -130.9^{\circ}$$

**J 17.** (a) 
$$\theta = \cos^{-1}\frac{4}{7}$$
 (b)  $v = \sqrt{\frac{4}{7}gr}$  (c)  $\frac{k_T}{k_R} = 6$ 

**J 18.** 
$$\sqrt{\frac{27}{7}g(R-r)}$$

**J 19.** (a) mg(H-R-R sin
$$\theta$$
), (b)  $\frac{10}{7}$  g  $\left(\frac{H}{R} - 1 - \sin\theta\right)$ 

$$-\frac{5}{7}$$
 g cos $\theta$  (c) 4.9 N, 0.196 N upward

**J 20.** (i) (a) 
$$\frac{1.2g}{\ell}$$
 (cw) (b)  $-03.(\hat{i} + 2\hat{j})$  g (ii) (a)  $24g/17 \ell$  (cw) (b)  $12g/17 \downarrow$ 

(iii) 
$$2.4 \,\mathrm{g}/\ell$$
 (cw) (b)  $0.5 \,\mathrm{g} \downarrow$ 

**J 21.** 
$$\frac{9\pi + 16}{18\pi}$$

J 22. 
$$F_{max} = 3kmg/(2-3k);$$
  $w_{max} = 2kg/(2-3k)$ 

J 23. 
$$w = 3g (M + 3m) / (M + 9m + I/R^2)$$

#### SECTION (K):

**K 1.** (a) 
$$v = 0$$
 (b)  $\omega = \frac{v}{5a}$  (c)  $\frac{3}{5}$  mv<sup>2</sup>

**K 2.** 
$$\frac{\mathsf{v}_0}{3} \ (\leftarrow), \frac{2\mathsf{v}_0}{3} \ (\rightarrow)$$

**K 3.** (a) 
$$\frac{Ft}{m}$$
 (b)  $\frac{6Ft}{m\ell}$  (c)  $\frac{2 F^2 t^2}{m}$  (d)  $\frac{F\ell t}{2}$ 

K 4. 
$$\frac{\pi L}{12}$$

**K 5.** 
$$\omega = \frac{1.7 \text{v}}{2\text{R}} \text{ V}_{\text{min}} = \frac{2}{1.7} \sqrt{0.3 \text{gR}}$$

**K 7.** 
$$\omega R/3$$

**K 9.** (a) 
$$\frac{5\overline{v}_0}{2r}$$
 (ccw) (b)  $\frac{v_0}{\mu_k g}$ 

**K 10.** (a) 
$$t = \frac{6a\pi}{\sqrt{3}v_0}$$

(b) 
$$s = \frac{a}{\sqrt{3}} \sqrt{1 + (2\pi + \sqrt{3})^2}$$

**K 11.** (a) 
$$\frac{\text{mL}\sqrt{\text{gh}}}{\sqrt{2}}$$
,  $\sqrt{\frac{8\text{gh}}{3\text{L}}}$  (b)  $\frac{3}{2}$  L

**K 13.** 
$$\omega = \frac{\overline{v}_1}{L} \frac{12 \sin \beta}{3 \sin^2 \beta + 1} \text{ (cw)}$$

**K 14.** 
$$H = \left(\frac{1 - 3\cos^2\theta}{1 + 3\cos^2\theta}\right)^2$$
;  $h = \frac{49 \pi \ell}{144}$ 

#### SECTION (L):

L 1. 
$$\frac{1}{2}$$
 mg a sin $\theta$ 

## Exercise - 3

1. **(a)** 
$$v = \frac{2v_0}{3}$$
;  $t_0 = \frac{v_0}{3} \mu g$ 

**(b)** 
$$w = -\mu mg (v_0 t - \frac{3}{2} \mu g t^2); - \frac{1}{6} m v_0^2$$

2. 
$$\frac{\text{mg}}{6}$$
, up

(b) 
$$\vec{\tau}_1 = 0.6 \hat{k} - 0.6 \hat{j}$$
,  $\vec{\tau}_2 = -0.6 \hat{k} - 0.6 \hat{j}$ 

6. 
$$w(d-x)/d$$
,  $wx/d$ 

7. (a) 
$$\vec{F} = \frac{2mV}{\Delta t}\hat{i} - \frac{2mV}{\sqrt{3}\Delta t}\hat{k}$$
;  $\vec{N} = \left(\frac{2mV}{\sqrt{3}\Delta t} + mg\right)\hat{k}$ ,

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(b) 
$$\vec{\tau} = -\left(\frac{4mVh}{\sqrt{3}\Delta t}\right)\hat{j}$$

8. 
$$v = \sqrt{5gR}$$
 9. A

**13.** (a) 
$$a_c = \frac{4F}{3m_1 + 8m_2}$$
;  $a_p = \frac{8F}{3m_1 + 8m_2}$ 

 $= -\left(\frac{4\text{mVh}}{\sqrt{3}\Delta t}\right)\hat{j}$   $\sqrt{5\text{gR}}$ 9. A

C
11. C
12. C  $\frac{4\text{F}}{3\text{m}_1 + 8\text{m}_2}; a_p = \frac{8\text{F}}{3\text{m}_1 + 8\text{m}_2}$ friction at the top of the cylinder =  $3\text{m}_1 F/(3\text{m}_1 + 8\text{m}_2) \text{ towards right, friction at the bottom} = \text{m}_1 F/(3\text{m}_1 + 8\text{m}_2) \text{ towards right}$ 15. C
16. D
17. B

**18.** (a) 
$$\frac{m}{M} = \frac{1}{4}$$
 (b)  $AP = \frac{2L}{3}$  (c)  $V_p = \frac{V_0}{2\sqrt{2}}$ 

19. 20. 21. 
$$\theta = 60^{\circ}$$
 22. E

**24.** (a) 
$$x = 0.1 \text{ m}$$
 (b)  $\omega = 1 \text{ rad/s}$  (c) never

27. (a) 
$$\sqrt{3}$$
 m  $\omega^2 \ell$ 

(b) 
$$F_y = \sqrt{3} \text{ m } \omega^2 \ell \quad F_x = -F/4$$

**35.** 
$$\frac{3mv}{\ell(M+3m)}$$
 **36. A**