

MECHANICS 3 (A) TEST PAPER 5 : ANSWERS AND MARK SCHE

1. $\frac{\lambda}{0.3} \times 0.1 = 0.4 \times 9.8$ $\lambda = 11.76 \text{ N}$ M1 A1
 Energy : $0.4 \times 9.8 \times (0.15 + x) = \frac{11.76}{2 \times 0.3} x^2$ $0.06 + 0.4x = 2x^2$ M1 A1 A1
 $10x^2 - 20x - 3 = 0$ $(10x + 1)(10x - 3) = 0$ $x = 0.3 \text{ m}$ M1 A1 7
2. (a) Resultant force towards centre = $\frac{mv^2}{r}$ B1
 (b) Weight = mg , reaction R at angle θ to vertical $R \cos \theta = mg$ B1 B1 B1
 Horizontally : $R \sin \theta = \frac{mv^2}{r}$ Divide : $\tan \theta = \frac{v^2}{gr}$ M1 A1 A1 7
3. (a) $2T \sin 30^\circ = 0.2 \times 9.8$ $T = 1.96 \text{ N}$ M1 A1
 (b) P.E. loss = K.E. gain : $0.2 \times 9.8 \times r(\sin 60^\circ - \sin 30^\circ) = \frac{1}{2} \times 0.2v^2$ M1 A1 A1
 $T - 0.2g \cos 30^\circ = \frac{0.2v^2}{2r}$ $T = 1.96(0.732 + 0.866) = 3.13 \text{ N}$ M1 A1 A1 8
4. (a) $mg = k \frac{mx}{r}$ (given), so $k = gR^2$ B1
 (b) Equal periods, so $\frac{2\pi(4R)}{v_b} = \frac{2\pi(3R)}{v_a}$ $\frac{v_b}{v_a} = \frac{4}{3}$ M1 A1
 (c) $\frac{gR^2 m}{9R^2} - T = \frac{mv^2}{3R}$, $\frac{gR^2 m}{16R^2} + T = \frac{16mv^2}{9(4R)}$ M1 A1 A1
 $\frac{mg}{9} - T = \frac{mv^2}{3R}$, $\frac{mg}{16} + T = \frac{4mv^2}{9R}$ Solve : $T = \frac{37}{1008} mg$ M1 A1 A1 M1 A1 11
5. (a) $P : T = 0.06g$ $Q : 0.06g \cos \theta = 0.04g$ $\cos \theta = \frac{2}{3}$ B1 M1 A1 A1
 Hence $\frac{2}{3}(l - d) = d$ $d = \frac{2}{5} l$ M1 A1
 (b) $P : T \sin \beta = 0.06e \sin \beta \omega^2$ $T = 0.06e\omega^2$ M1 A1
 $Q : T \sin \alpha = 0.04(l - e) \sin \alpha \omega^2$ $T = 0.04(l - e)\omega^2$ M1 A1
 Equate : $3e = 2(l - e)$ $e = \frac{2}{5} l$ $OQ = \frac{3}{5} l$ M1 A1 A1 13
6. (a) Cup : S.A. = $2\pi r^2$, mass M Base : Area = πr^2 , so mass = $\frac{1}{2} M$ B1
 (b) M(base) : $M \frac{3r}{2} + m \frac{r}{2} = (M + \frac{M}{2} + m) \frac{13r}{14}$ M1 M1 A1 A1
 $42M + 14m = 39M + 26m$ $3M = 12m$ $M = 4m$ M1 A1
 (c) M(base) : $\frac{7M}{4} \frac{13r}{14} + 2M \frac{13r}{8} = (2M + \frac{7M}{4}) \bar{y}_1$ $\bar{y}_1 = \frac{13r}{10}$ M1 A1 M1 A1 A1
 C. of M. rises by $\frac{13r}{10} - \frac{13r}{14} = \frac{13r}{35}$ A1
 (d) Assumed liquid is a solid hemisphere B1 14
7. (a) (i) At displ. x , $T - mg = -m\ddot{x}$ $T = \frac{\lambda}{l}(e + x)$ $mg = \frac{\lambda}{l}e$ M1 A1 B1 B1
 $\frac{\lambda e}{l} + \frac{\lambda x}{l} - mg = -m\ddot{x}$ $m\ddot{x} = -\frac{\lambda}{ml}x$ Hence SHM about C M1 A1
 (ii) Period = $2\pi \sqrt{\frac{lm}{\lambda}}$ (iii) String must not go slack B1; B1
 (b) (i) m becomes $m + M$, so $T_1 = 2\pi \sqrt{\frac{(m+M)l}{\lambda}}$ M1 A1
 (ii) $T_1^2 - T^2 = \frac{4\pi^2}{\lambda} [l(m+M) - lm] = \frac{4\pi^2}{\lambda} lM$ M1 A1
 At D, $(m + M)g = \frac{\lambda}{l}(e + d)$, so $\frac{\lambda d}{l} = Mg$ $T_1^2 - T^2 = \frac{4\pi^2 d}{g}$ M1 A1 A1 15