

|   |                                                       |  |  |  |
|---|-------------------------------------------------------|--|--|--|
| 1 | $T \cos \theta = mg$                                  |  |  |  |
|   | $T \sin \theta = m\omega^2 r$                         |  |  |  |
|   | $\frac{5}{3}mg \sin \theta = m\omega^2 a \sin \theta$ |  |  |  |
|   | $\omega = \sqrt{\frac{5g}{3a}}$                       |  |  |  |
|   |                                                       |  |  |  |

|                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                      |                    |                                         |                           |        |                    |                                         |                           |                    |                 |                |           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------------------------------------|---------------------------|--------|--------------------|-----------------------------------------|---------------------------|--------------------|-----------------|----------------|-----------|
| 4                                                                                                                                                                           | <table><tr><td>Areas</td><td><math>2a^2</math></td><td><math>\frac{1}{2}a(2a)</math></td><td><math>2a^2 + \frac{1}{2}a(2a)</math></td></tr><tr><td>Distances from <math>D</math></td><td><math>-\frac{1}{2}a</math></td><td><math>\frac{2}{3}a</math></td><td><math>\bar{x}</math></td></tr></table> |                    |                                         |                           | Areas  | $2a^2$             | $\frac{1}{2}a(2a)$                      | $2a^2 + \frac{1}{2}a(2a)$ | Distances from $D$ | $-\frac{1}{2}a$ | $\frac{2}{3}a$ | $\bar{x}$ |
|                                                                                                                                                                             | Areas                                                                                                                                                                                                                                                                                                | $2a^2$             | $\frac{1}{2}a(2a)$                      | $2a^2 + \frac{1}{2}a(2a)$ |        |                    |                                         |                           |                    |                 |                |           |
|                                                                                                                                                                             | Distances from $D$                                                                                                                                                                                                                                                                                   | $-\frac{1}{2}a$    | $\frac{2}{3}a$                          | $\bar{x}$                 |        |                    |                                         |                           |                    |                 |                |           |
|                                                                                                                                                                             | $-2a^2\left(\frac{1}{2}a\right) + \frac{1}{2}\left(2a^2\right)\left(\frac{2}{3}a\right) = \left(3a^2\right)\bar{x}$                                                                                                                                                                                  |                    |                                         |                           |        |                    |                                         |                           |                    |                 |                |           |
|                                                                                                                                                                             | $m\left(\frac{1}{9}a\right) = km(2a)$                                                                                                                                                                                                                                                                |                    |                                         |                           |        |                    |                                         |                           |                    |                 |                |           |
|                                                                                                                                                                             | $k = \frac{1}{18}$                                                                                                                                                                                                                                                                                   |                    |                                         |                           |        |                    |                                         |                           |                    |                 |                |           |
|                                                                                                                                                                             | Alternative method for question 4                                                                                                                                                                                                                                                                    |                    |                                         |                           |        |                    |                                         |                           |                    |                 |                |           |
| <table><tr><td>Ratio of masses</td><td><math>2a^2</math></td><td><math>\frac{1}{2}a(2a)</math></td><td><math>k\left(2a^2 + \frac{1}{2}a(2a)\right)</math></td></tr></table> |                                                                                                                                                                                                                                                                                                      |                    |                                         | Ratio of masses           | $2a^2$ | $\frac{1}{2}a(2a)$ | $k\left(2a^2 + \frac{1}{2}a(2a)\right)$ |                           |                    |                 |                |           |
| Ratio of masses                                                                                                                                                             | $2a^2$                                                                                                                                                                                                                                                                                               | $\frac{1}{2}a(2a)$ | $k\left(2a^2 + \frac{1}{2}a(2a)\right)$ |                           |        |                    |                                         |                           |                    |                 |                |           |
| $2\left(\frac{1}{2}a\right) = 1\left(\frac{2}{3}a\right) + 3k(2a)$                                                                                                          |                                                                                                                                                                                                                                                                                                      |                    |                                         |                           |        |                    |                                         |                           |                    |                 |                |           |
| $k = \frac{1}{18}$                                                                                                                                                          |                                                                                                                                                                                                                                                                                                      |                    |                                         |                           |        |                    |                                         |                           |                    |                 |                |           |
|                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                      |                    |                                         |                           |        |                    |                                         |                           |                    |                 |                |           |
|                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                      |                    |                                         |                           |        |                    |                                         |                           |                    |                 |                |           |

|   |                                                                                                            |
|---|------------------------------------------------------------------------------------------------------------|
| 1 | Let $v_A$ and $v_B$ be the speeds of $A$ and $B$ respectively after the collision.<br>$4mv_A + mv_B = 4mu$ |
|   | $-v_A + v_B = eu$                                                                                          |
|   | $v_A = \frac{3}{4}u, \quad v_B = u$                                                                        |
|   | $e = \frac{1}{4}$                                                                                          |
|   | <b>Alternative method for question 1</b>                                                                   |
|   | Let $v_A$ and $v_B$ be the speeds of $A$ and $B$ respectively after the collision.<br>$4mv_A + mv_B = 4mu$ |
|   | $-v_A + v_B = eu$                                                                                          |
|   | $v_A = \frac{1}{5}u(4-e), \quad v_B = \frac{4}{5}u(1+e)$                                                   |
|   | $\frac{4m\left(\frac{1}{5}u(4-e)\right)}{m\left(\frac{4}{5}u(1+e)\right)} = 3, \quad e = \frac{1}{4}$      |
|   |                                                                                                            |

2

$$\uparrow N_1 \cos \theta_1 = mg$$

$$\rightarrow N_1 \sin \theta_1 = m(r \sin \theta_1) \omega_1^2$$

$$\uparrow N_2 \cos \theta_2 = mg$$

$$\rightarrow N_2 \sin \theta_2 = m(r \sin \theta_2) \omega_2^2$$

$$\frac{\frac{5}{4}g}{\frac{5}{3}g} = \frac{r\omega_1^2}{r\omega_2^2}$$

$$\frac{\omega_1}{\omega_2} = \frac{1}{2}\sqrt{3}$$

1

$$T_A \cos 45^\circ + T_B \sin 45^\circ = m\omega^2 l \sin 45^\circ$$

$$T_A \sin 45^\circ - T_B \cos 45^\circ = mg$$

$$2T_A = m\omega^2 l + \sqrt{2}mg$$

$$T_A = \frac{1}{2}m(\omega^2 l + \sqrt{2}g)$$