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MECHANICS 2 (A) TEST PAPER 9 : ANSWERS AND MARK SCHE

1. $m(5\mathbf{i} + 6\mathbf{j}) + 2m\mathbf{u} = m(-3\mathbf{i} + 2\mathbf{j}) + 2m(\mathbf{i} - 3\mathbf{j})$ M1 A1

   $5\mathbf{i} + 6\mathbf{j} + 2\mathbf{u} = -\mathbf{i} - 4\mathbf{j}$ $\quad 2\mathbf{u} = -6\mathbf{i} - 10\mathbf{j}$ $\quad \mathbf{u} = (-3\mathbf{i} - 5\mathbf{j})\ \text{ms}^{-1}$ M1 A1 A1 — 5

2. Gain in K.E. $= \frac{1}{2} \times 55 \times (2{\cdot}5^2 - 1{\cdot}5^2) = 110$ J M1 A1

   Gain in P.E. $= 55g(80 \sin 6°) = 4507$ J M1 A1

   Work done = total energy gain = 4617 J M1 A1 — 6

3. (a) $\mathbf{r} = t^2\mathbf{i} - \frac{2}{3}t^{\frac{3}{2}}\mathbf{j} - 10\mathbf{i} + \mathbf{j} = (t^2 - 10)\mathbf{i} + (1 - \frac{2}{3}t^{\frac{3}{2}})\mathbf{j}$ M1 M1 A1 A1

   (b) When $t = 4$, $\mathbf{r} = -6\mathbf{i} - \frac{13}{3}\mathbf{j}$ $\quad |\mathbf{r}| = 7{\cdot}40$ m M1 A1 A1 — 7

4. (a) $s = \frac{1}{2}at^2$: if time is doubled, acceleration is divided by 4 M1

   so net acc. $= \frac{1}{4}g$ $\quad mg - R = ma$ $\quad R = \frac{3}{4}g(0{\cdot}6) = 4{\cdot}41$ N A1 M1 A1

   (b) $v^2 = 2as = \frac{1}{2}g(2) = 9{\cdot}8$ $\quad v = 3{\cdot}13\ \text{ms}^{-1}$ M1 A1 A1 — 7

5. (a) $M(2{\cdot}5) + 2m(1) = (M + 2m)\bar{x}$ $\quad \bar{x} = \frac{5M+4m}{2M+4m}$ M1 A1 M1 A1

   (b) $5M + 4m = 2{\cdot}2(2M + 4m)$ $\quad 0{\cdot}6M = 4{\cdot}8m$ $\quad M : m = 8 : 1$ M1 A1 A1 — 7

6. (a) $x = (u\cos\theta)t$, $\quad y = h + (u\sin\theta)t - \frac{1}{2}gt^2$ B1 M1 A1

   $y = h + x\tan\theta - \frac{g}{2}\frac{x^2}{u^2\cos^2\theta}$ $\quad 0 = h + d\tan\theta - \frac{gd^2}{2u^2\cos^2\theta}$ M1 A1 M1

   $\frac{gd^2}{2u^2}\sec^2\theta - d\tan\theta - h = 0$ A1

   (b) Let $\tan\theta = T$ $\quad$ Subst. given values : $4{\cdot}9(1 + T^2) - 14T - 7 = 0$ M1 A1

   $7T^2 - 20T - 3 = 0$ $\quad (7T + 1)(T - 3) = 0$ $\quad T = 3$ $\quad \theta = 71{\cdot}7°$ M1 A1 A1 — 12

7. (a) $P = Fv = 210$ W M1 A1

   (b) $210 = v(42 + 84g\sin\alpha)$ $\quad v = 210 \div (42 + 4g) = 2{\cdot}59\ \text{ms}^{-1}$ M1 A1 M1 A1

   (c) $R = kv$ $\quad 42 = 5k$, so $k = 8{\cdot}4$ M1 A1

   $210 = v(8{\cdot}4v + 4g)$ $\quad 8{\cdot}4v^2 + 39{\cdot}2v - 210 = 0$ M1 A1 A1

   $3v^2 + 14v - 75 = 0$ $\quad v = (-14 + \sqrt{1096})/6 = 3{\cdot}18\ \text{ms}^{-1}$ A1 M1 A1 — 14

8. (a) Momentum : $mu - kmu = -m\frac{u}{5} + kmv$ $\quad \frac{6u}{5} - ku = kv$ M1 M1 A1

   $v = u\left(\frac{6}{5k} - 1\right)$ A1

   (b) Elasticity : $(v + \frac{u}{5}) / (-u - u) = -e$ $\quad v = 2eu - \frac{u}{5} = u\left(2e - \frac{1}{5}\right)$ M1 A1 M1 A1

   (c) $v > 0$, so $\frac{6}{5k} > 1$ $\quad k < \frac{6}{5}$ $\quad$ Also $2e > \frac{1}{5}$ $\quad e > \frac{1}{10}$ M1 A1 M1 A1

   Hence $\frac{1}{10} < e \le 1$, so $0 < v \le \frac{9u}{5}$ $\quad 0 < \frac{6}{5k} - 1 \le \frac{9}{5}$ M1 A1

   $\frac{6}{5k} \le \frac{14}{5}$ $\quad 14k \ge 6$ $\quad k \ge \frac{3}{7}$ $\quad p = \frac{3}{7}, q = \frac{6}{5}$ M1 A1 A1 — 17

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