Mechanics 2

Edexcel IAL M2 (WME02/01); the applied unit after M1 in IAL Mathematics

1. Unit M2 at a glance

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WME02/01: 1 hour 30 minutes, 75 marks, $g = 9.8\ \mathrm{m\,s^{-2}}$ unless the model says otherwise (one June 2025 question uses 10). Must-know: KE $\frac{1}{2}mv^2$, PE mgh, work Fs, power Fv, restitution $e = \frac{v_B - v_A}{u_A - u_B}$.

2. Kinematics with variable acceleration

Variable acceleration

$v = \int a\,dt$, $s = \int v\,dt$ with constants from the initial conditions; total distance via the $v = 0$ turning point ($27 + 27 = 54$, not 27). Vectors: $\mathbf{v} = \frac{d\mathbf{r}}{dt}$, then impulse $\mathbf{I} = m\Delta\mathbf{v}$ at the stated instant: $\mathbf{r} = 4\sqrt{t}\,\mathbf{i} - 3t\mathbf{j}$ gives $\mathbf{i} - 3\mathbf{j}$ at $t = 4$, and impulse $(6\mathbf{i} - 3\mathbf{j})$ gives speed 5.

3. Centres of mass

Centres of mass

Table method: weight by area (lamina) or length (wire); booklet gives semicircular wire $\frac{2r}{\pi}$, lamina $\frac{4r}{3\pi}$. Opposite-side pieces are NEGATIVE: the S-framework's moments $2\pi a \cdot \frac{4a}{\pi} - \pi a \cdot \frac{2a}{\pi} = 6a^2$ over $(3\pi + 2)a$ give $\overline{x} = \frac{6a}{3\pi+2}$.

4. Suspending laminas and frameworks

Suspension

Freely suspended, G sits below the point of suspension. The S-framework from A with E at $\angle AOE = 90°$: G on OE, $\tan \angle OAG = \frac{3}{3\pi+2}$, and $\theta = 45° - \angle OAG$ (isosceles AOE), giving $\tan\theta = \frac{3\pi-1}{3\pi+5}$.

5. Work, energy and power

Energy and power

$P = Fv$: at 20 kW on a slope with $\sin\alpha = \frac{1}{7}$, $\frac{20000}{V} = 1250$ gives $V = 16$; at 10, $a = 1$. Work-energy: resistance over slope distance, gravity over height: $37500 = 1250d$, $d = 30$ m. Projectiles by energy: components V and $2V$ at 11 m give $V = 6$; perpendicular to a $60°$ plane fixes the direction, speed $8\sqrt{3}$, so $H = 10$ m.

6. Collisions and restitution

Collisions

Momentum + $e = \frac{v_B - v_A}{u_A - u_B}$: $2m$ at u into m at rest gives $v_Q = \frac{2(1+e)u}{3}$, $v_P = \frac{(2-e)u}{3}$. KE after $= \frac{mu^2}{3}(2+e^2)$, loss $= \frac{1}{3}(1-e^2)mu^2$; impulse on Q $= mv_Q$ closes $e = \frac{1}{3}$.

7. Successive impacts

Successive impacts

A fixed wall scales speed by its restitution and reverses direction — no momentum equation. After the first collision ($e = \frac{1}{3}$): $v_Q = \frac{8}{9}u$, $v_P = \frac{5}{9}u$; Q rebounds to match P: $f \cdot \frac{8}{9}u = \frac{5}{9}u$, so $f = \frac{5}{8}$. Stage-by-stage signed diagrams; equate only what the question ties.

8. Statics of rigid bodies

Rigid bodies

Moments about the unknown-killing pivot: rod on a smooth rail at $AC = 1.5a$: $S(1.5a) = mga\cos\theta$, $S = \frac{2mg\cos\theta}{3}$; $V = mg - S\cos\theta = \frac{mg}{3}(3 - 2\cos^2\theta)$. Limiting with $\mu = \frac{4}{7}$: $F = S\sin\theta$ becomes $6\tan^2\theta - 7\tan\theta + 2 = 0$ via $\sec^2\theta = 1 + \tan^2\theta$.

Check yourself

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Integrate variable acceleration with constants and turning points; vector velocity then impulse; COM tables with signed pieces and holes; suspension angles; $P = Fv$ both ways; work-energy on slopes; momentum + restitution with the $(1 - e^2)$ loss; wall rebounds in chains; rigid-body moments with the sec-squared finish.