Mechanics 1

Edexcel IAL M1 (WME01/01); models, vectors, kinematics, forces, momentum, statics and moments

Formulae to memorise

Family	**Must know**
momentum	mv; **impulse** $= mv - mu$
suvat	$v = u + at$, $s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$
forces	**resultant** $= ma$; weight mg; $F = \mu R$ moving
vectors	$\lvert a\mathbf{i} + b\mathbf{j}\rvert = \sqrt{a^2 + b^2}$

The words are instructions

Word	**What it buys you**
particle	mass, no size: no turning
light	massless: **tension** unchanged along it
uniform	centre of mass at the midpoint
inextensible	both ends move at the same speed
smooth	no friction
smooth **pulley**	changes direction, not size

Bearings from components

$-5\mathbf{i} - 12\mathbf{j}$: **bearing** $203°$

- $\mathbf{i}$ east, $\mathbf{j}$ north.
- Find the quadrant first.

Worked: position vectors

1. **Velocity** $\frac{15\mathbf{i}-12\mathbf{j}}{3} = 5\mathbf{i} - 4\mathbf{j}$
2. **Position** $\mathbf{r}_A = (5t - 15)\mathbf{i} + (24 - 4t)\mathbf{j}$
3. **At t = 5** $\overrightarrow{AB} = (5\mathbf{i} - 8\mathbf{j}) - (10\mathbf{i} + 4\mathbf{j})$

Decision

$\overrightarrow{AB} = -5\mathbf{i} - 12\mathbf{j}$: **bearing** $203°$

Worked: up and down

1. **Signs** up positive, origin at A: $s = -12$, $t = 4$, $a = -9.8$
2. **Launch** $-12 = 4U - 4.9(16)$: $U = 16.6\ \mathrm{m\,s^{-1}}$
3. **Landing** $v^2 = 16.6^2 + 2(9.8)(12) = 510.8$

Decision

Hits the ground at $22.6\ \mathrm{m\,s^{-1}}$

The speed-time V

> Speed cannot go negative: up then down is a V.

- Velocity-time: gradient is acceleration.
- Area is displacement.

Across the canal, nothing accelerates

$800 \sin 25^\circ = 500 \sin \alpha$: $\alpha = 43^\circ$

- Resolve along and across.
- $F = ma$ in each direction.

Worked: the pulley

1. **P up** $T - kMg = kM \cdot \frac{g}{5}$
2. **Q down** $3Mg - T = 3M \cdot \frac{g}{5}$
3. **Eliminate T** $5(3-k) = 3 + k$: $k = 2$

Decision

Force on the **pulley** $2T = 23.5$ N, with $M = 0.5$ kg

Worked: one impulse, two bodies

1. **On Q** $3m(v-2u)=4.5mu$: $v=3.5u$
2. **On P** equal and opposite: $km(5u-2u)=4.5mu$
3. **Solve** $3k=4.5$

Decision

$k=1.5$

Friction: moving or limiting

Moving

$F = \mu R$

always

At rest

$F \leq \mu R$

"on the point of moving": $F = \mu R$

Worked: a package on a rough slope

1. **Perpendicular** $R = mg\cos\theta = \frac{4}{5}mg$
2. **Along, sliding up** $-mg\cdot\frac{3}{5} - \frac{1}{4}\cdot\frac{4}{5}mg = ma$: $a = -\frac{4}{5}g$
3. **Held by X** $X + \frac{1}{4}(2g\cdot\frac{4}{5}) = 2g\cdot\frac{3}{5}$

Decision

$X = \frac{4}{5}g = 7.84$ N

Three forces in equilibrium

Resultant zero: both totals vanish.

- Resolve in two directions.
- Or close the triangle.

Each tilt has its own pivot

$$d = \frac{24a}{17}$$

- Zero moment about ANY point.
- Tilting about X: the other reaction is zero.

Check yourself

Question	**Answer**
Light string: **tension**?	the same throughout
Area under a v-t graph?	displacement
Force on a smooth **pulley**?	$2T$
When is $F = \mu R$ at rest?	on the point of moving
Pivot for moments?	the one that kills unknowns