"The Knowledge" FOR MECHANICS MAJOR - Answers

The equation for F_{max} in terms of the coefficient of friction

$F_{max} = \mu R$

The meaning of a couple

A set of forces with zero resultant force but a non-zero total moment

The definition of Work Done by a force

Work Done = Force x Displacement in the direction of that force

The Work-Energy Principle (WEP)

Initial Energy + Work Done = Final Energy

The two definitions of Power

$P = Fv = \frac{WD}{t}$

The definition of Impulse

Impulse $= Ft$

The Principle of Impulse

Impulse $= mv - mu$ (change in momentum)

The definition of the coefficient of restitution, its bounds, and the significance of it attaining these bounds

$e = \frac{\text{separating speed}}{\text{approach speed}}$, $0 \leq e \leq 1$.

When $e = 1$, the collision is perfectly elastic and no kinetic energy is lost.

When $e = 0$, the collision is inelastic and the bodies coalesce.

The centre of mass $(\bar{x}, \bar{y})$ of a uniform lamina

$A\bar{x} = \int xy \, dx$
$A\bar{y} = \frac{1}{2}\int y^2 \, dx$, where $A = \int y \, dx$

or (if easier)

$A\bar{x} = \frac{1}{2}\int x^2 \, dx$
$A\bar{y} = \int xy \, dx$, where $A = \int x \, dy$

The x-coordinate of the centre of mass of a uniform solid of revolution rotated about the x-axis

$V\bar{x} = \pi\int xy^2 \, dx$, where $V = \pi\int y^2 \, dx$ (and just switch x and y if rotated about the y-axis)

The relationship between tangential velocity and angular velocity

$v = r\omega$

The relationship between tangential acceleration and angular acceleration

$a = r\frac{d^2\theta}{dt^2} = r\alpha$

Two expressions for centripetal acceleration given circular motion

$a = \frac{v^2}{r} = \omega^2 r$, where v is tangential velocity and $\omega = \frac{d\theta}{dt}$ is angular velocity

Three different ways of expressing acceleration as a derivative

$a = \frac{dv}{dt} = v\frac{dv}{dx} = \frac{1}{2}\frac{d}{dx}(v^2)$

Tension in a string or spring in terms of stiffness or modulus of elasticity

$T = kx = \frac{\lambda x}{l}$, where x is extension and l is the natural length

Elastic potential energy in terms of stiffness or modulus of elasticity

$EPE = \frac{kx^2}{2} = \frac{\lambda x^2}{2l}$, where x is extension and l is the natural length

How to find the bounding parabola of a projectile

Get the equation of the trajectory, treat as a disguised quadratic in $\tan\theta$, and set the discriminant equal to 0

The differential equation for simple harmonic motion and general solutions

$\frac{d^2x}{dt^2} = -\omega^2 x$ and $x = a\sin(\omega t + \epsilon)$ or $a\cos(\omega t + \epsilon)$ or $P\sin(\omega t) + Q\sin(\omega t)$

Given simple harmonic motion, the expression for the time period and frequency of oscillations

$T = \frac{2\pi}{\omega}$ and $f = \frac{\omega}{2\pi}$

Given simple harmonic motion, the relationship between velocity and displacement

$v^2 = \omega^2(a^2 - x^2)$

Given simple harmonic motion, the maximum velocity and maximum acceleration, and where the occur

$v_{max} = \omega a$ (occurring at equilibrium position) and $accel_{max} = \omega^2 a$ (occurring at maximum displacement)

The (approximate) differential equation for a pendulum given a small angular displacement

$\frac{d^2\theta}{dt^2} = -\frac{g}{l}\theta$ where *l* is the length of the string