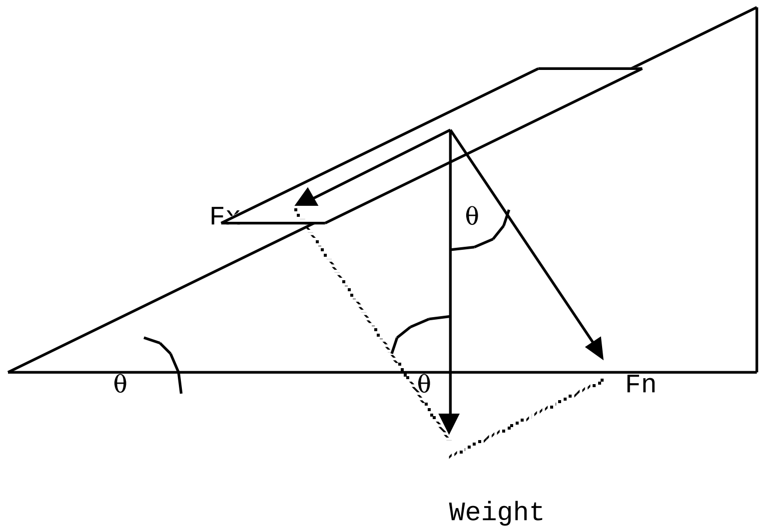
Option A - Mechanics

A.1 Dynamics

A.1.1



Weight is resolved into two components, Fx and Fn. Fn is called the normal force and acts <u>perpendicular to the incline.</u> Fx, the second component acts parallel to and down the incline.

Formula: *sin (θ) = Fx / Weight*

Cos (θ) = Fn / Weight

A.1.2

The nature of surfaces and normal force affects the amount of friction for solids (surface area and velocity do not).

For fluids, friction increases w/ relative speed and can produce a terminal speed.

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A.2 Projectile motion

A.2.1

Horizontal and Vertical motion are independent.

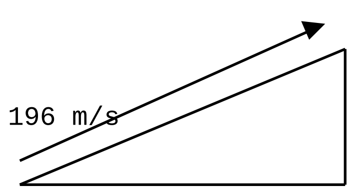
Horizontal displacement = horizontal vel. * time :: S(h)=V(h)*t

<u>Projectiles Fired at an Angle</u>

i.e.:

Object fired at 196m/s at an angle of 30 degrees.

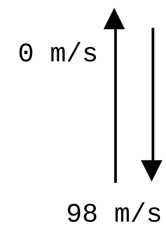
Find the Horizontal Displacement.



θ

Therefore, Vel. UPWARDS = sin(30)*196 = 98 m/s
Vel. Horizontal = cos(30)*196 = 170 m/s

Therefore, time going up: (a=Δv / t) t = Δv/a
t = 98/9.8 = 10 s
Therefore total time = 2 * 10 = 20s

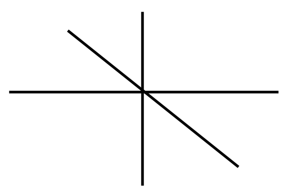


Horizontal displacement = 170 * 20 = 3400 m

A.3 Simple Harmonic motion

A.3.1

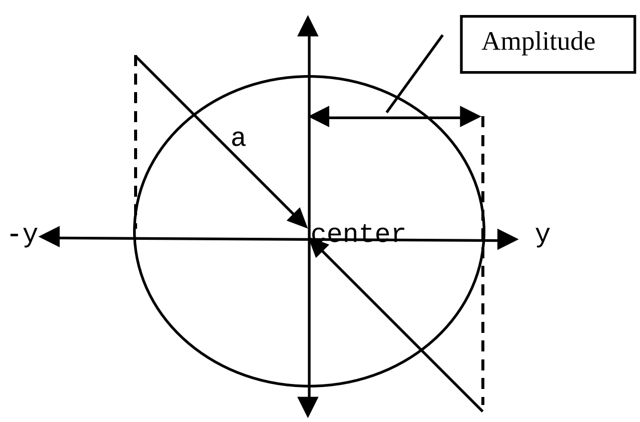
Simple Harmonic Motion: Motion in which a particle repeats a same path periodically // If the acceleration of a body is directly proportional to its distance from a fixed point and is always directed towards that point, the motion is simple harmonic.



Acceleration-displacement Graph.

A.3.2

The period (T) describes the time taken to complete a full circle.
Thus, T=2π/ω



a = acceleration, y = displacement

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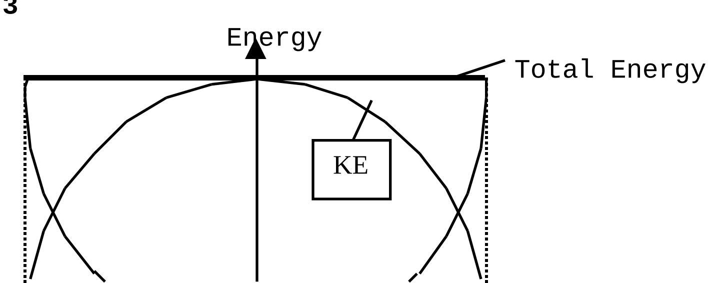
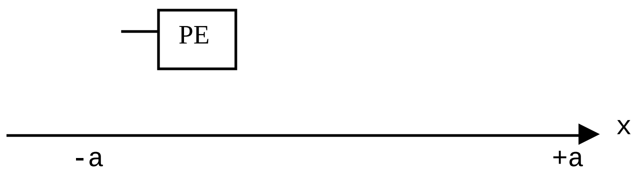
A.3.3





A.3.4

SHM in a mass on a light vertical spring:
The extension [x] of a spring (if the elastic limit is not exceeded) is proportional to the tension (force) [T]. (therefore T=kx) If however, the elastic limit of the spring is exceeded then the mass would no longer oscillate with SHM.

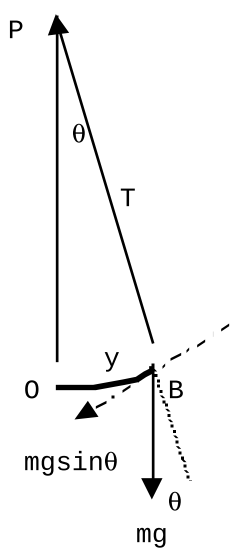
$$T = 2\pi * \sqrt{\frac{m}{k}}$$

and $$T = 2\pi * \sqrt{\frac{e}{g}}$$

Where e = extension length, k = spring constant.

A.3.5

Simple Pendulum motion approximates to SHM for small amplitude oscillations:



Suppose vibrating mass is at B where OB = y and OPB = θ.

- The force pulling towards O is at a tangent at B and equal to mgsinθ. Force=ma, therefore -mgsinθ = ma where a is the acc. along arc OB (the minus indicates that the F is towards 0 whereas y is measured outwards from O)
- **When** θ **is small**, sin θ = θ in radians, also θ=y/l. therefore -mgθ = -mg(y/l) = ma

- Therefore a = $-(g/l)y = -\omega^2 y$ ($\omega^2 = g/l$)
- *Since the acceleration is proportional to the distance y from a fixed point, the motion of the vibrating mass is simple harmonic motion.*

It follows that since $T=2\pi/\omega$, $\mathbf{T=2\pi\sqrt{\frac{l}{g}}}$

A.4 Circular Motion

A.4.1 + A.4.2

Angular displacement: ($s = r\theta$)

Angular velocity: (ω = linear speed/radius // $v=r\omega$) the angle swept out in unit time by the radius joining the body to the centre of the circle (rad per second)

A.4.3

Centripetal Acceleration: always directed toward the center of the circle.

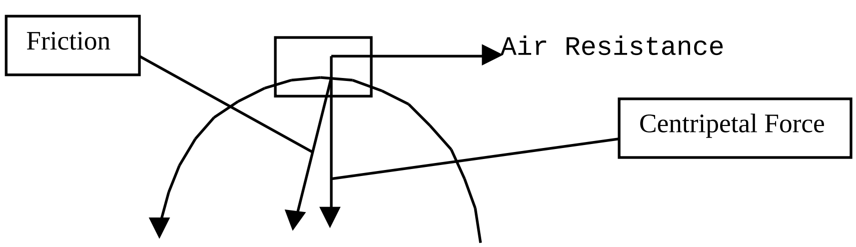
Acceleration = v^2/r [$v=r\omega$] therefore acceleration = $(r\omega)^2/r = r\omega^2$)

A.4.4

An object in uniform circular motion always has a *centripetal force* directed towards the centre.

$F(c) = m*a = m*(v^2/r) = 4\pi^2 mr/T^2 = mr\omega^2$

A.4.5



Example of a body in uniform circular motion (car on a bend)

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A.4.6
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A.4.7
KE = $1/2mv^2$ // Centripetal acceleration does not change the KE as it only changes the *direction* of velocity, not its speed.
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A.5 Universal Gravitation

A.5.1

Law of Universal Gravitation: (Newton)

Every particle of matter in the universe attracts every other particle with a force which is directly proportional to the product of their masses and inversely proportional to the square of their distances apart.

A.5.2

Gravitational field strength: the gravitational force acting on unit mass placed in the field (i.e.: earth's GF = 9.8 N per kg)

A.5.3

F= G* (Mm)/r^2 therefore mg = G*(Mm)/r^2 therefore <u>g = GM/r^2</u>
G = universal gravitational constant, M = mass of earth, m = mass of another object, r = distance between earth and second object.

Or gravitational field strength is *inversely proportional* to the distance apart *squared*.

<u>Note:</u> G = 6.67 x 10^{-11} Nm^2/kg^2

A.5.4

Gravitational potential: the potential energy per unit mass of a body in a gravitational field (theoretically zero at infinite distances)
A.5.5

Escape Velocity: the velocity required for a body to escape from a gravitational field.

_mv^2 = G(Mm)/r therefore v $\sqrt{\frac{2GM}{r}}$ =

Also, g = GM/r^2 therefore v = $\sqrt{2gr}$

A.6 Momentum and energy

A.6.1
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A.6.2
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A.6.3
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A.6.4

<u>Law of Conservation of mementum:</u> the total momentum of an isolated system cannot change.
Total Momentum(before collision) = Total Momentum(after collision)
m1v1 + m2v2 = m1v'1 + m2v'2

A.6.5