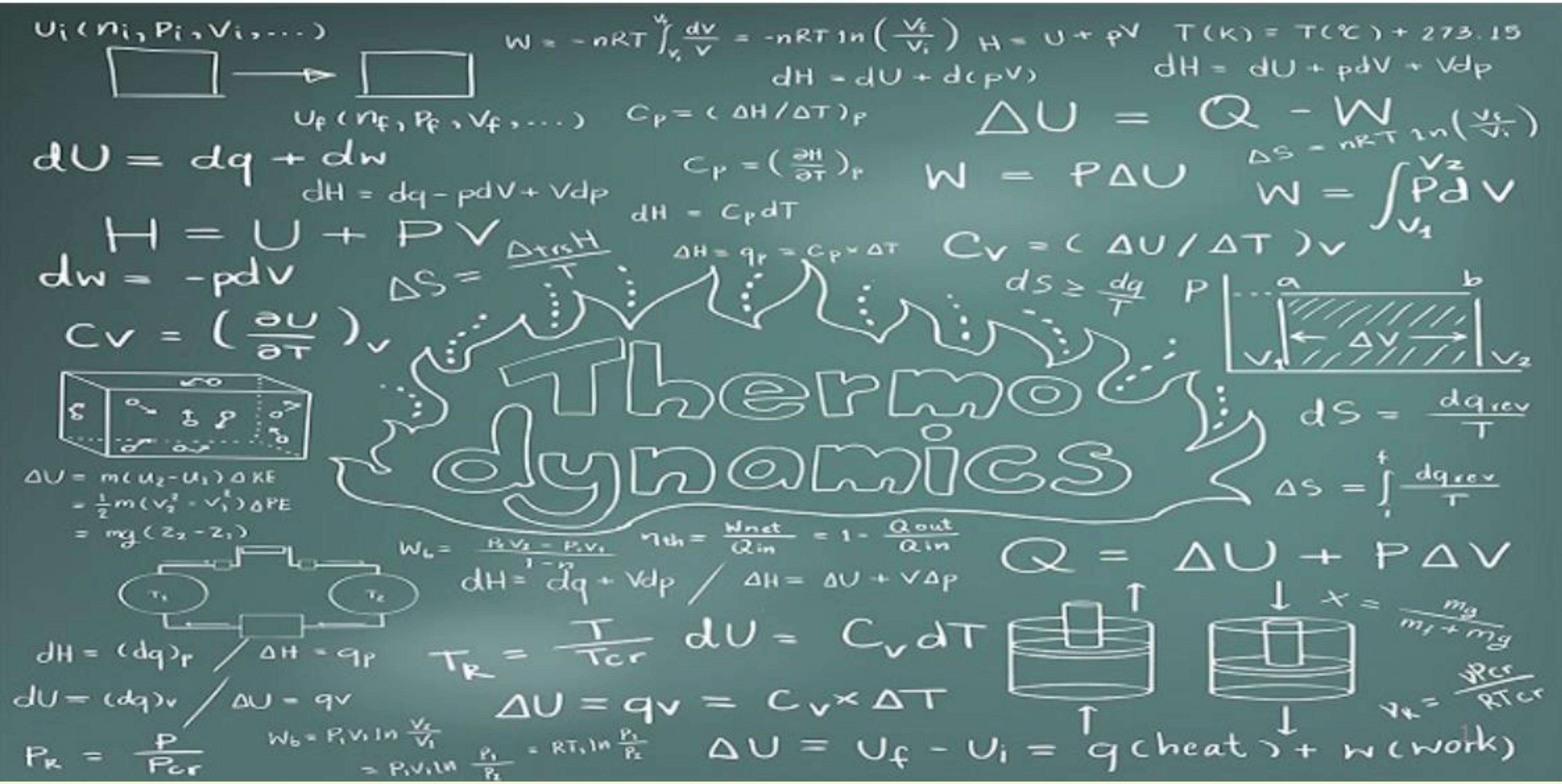
PHYS1013
Energy and Matter



Week 3 Module Survey: on Blackboard:

We hugely appreciate comments on the course at this stage when we can make changes

https://forms.office.com/e/ALn7gQ0Pya

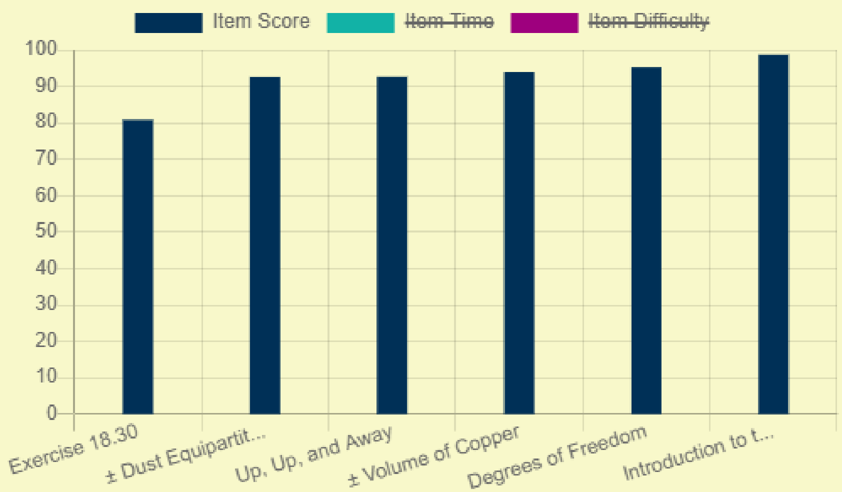
by 17:00 on Friday 16/02/2024

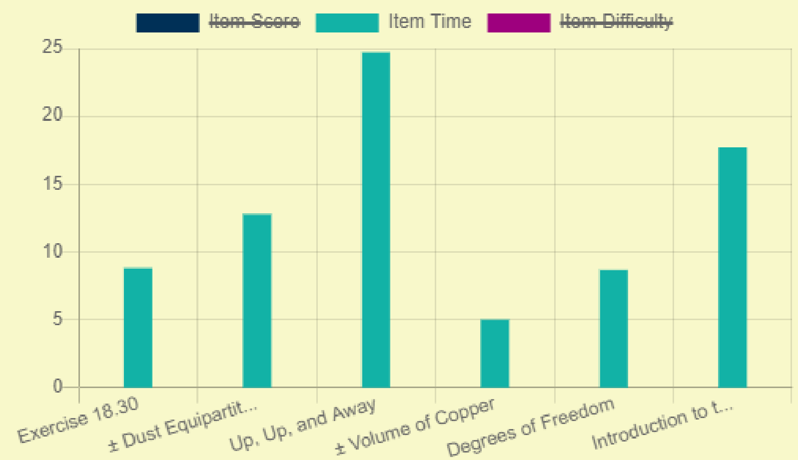
PHYS1013 Week 3 Survey

Recommend some good music – thank you to those avoiding Rick Astley

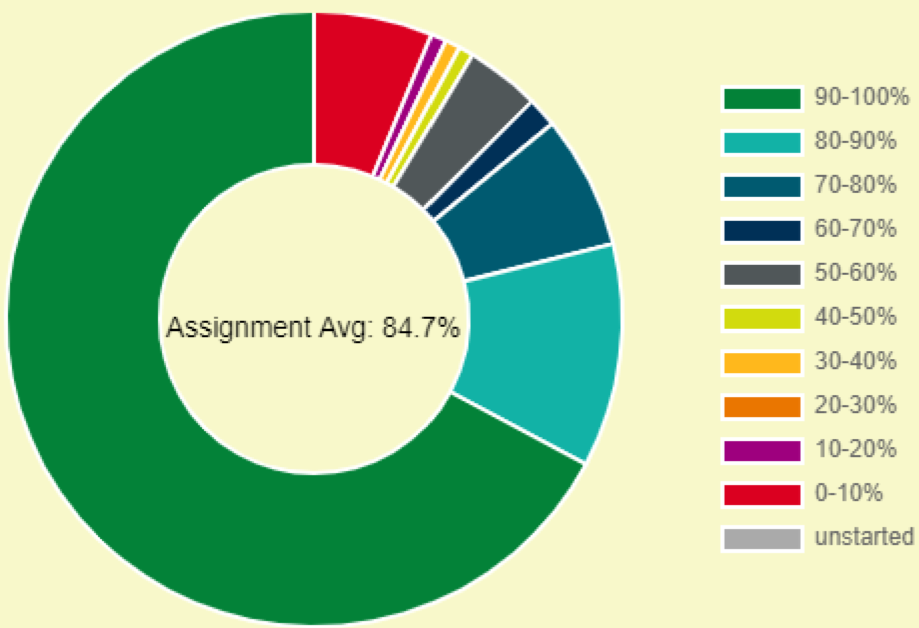
MP Week 1 – average score 90%

Average time 78 min





MP2 is due in this Sunday…



Distance Travelled On A Random Walk

The particle is constantly scattered randomly

$$\vec{r} = \vec{s}_1 + \vec{s}_2 + \dots$$

$$r^2 = \vec{r}\cdot\vec{r} = s_1^2 + s_2^2 + \dots + \vec{s}_1\cdot\vec{s}_2 + \vec{s}_2\cdot\vec{s}_1 + \dots$$

As we saw before in a random environment

$$\langle \cos\theta_{12} \rangle = 0 \qquad \vec{s}_1\cdot\vec{s}_2 = 0$$

$$\Rightarrow \quad r^2 = \sum_{i=1}^{N} s_i^2 \simeq N\lambda^2$$

assume go λ each step.

$$\boxed{r = \sqrt{N}\,\lambda}$$

Note that since $N \propto t$ (more collisions in more time)

$$r \propto t^{1/2}$$

If one were to simulate a finite step walk particle by particle then $\langle \cos\theta_{12} \rangle \neq 0$ precisely... one gets a distribution of distances travelled

As $N \to \infty$ the Gaussian like peak narrows....

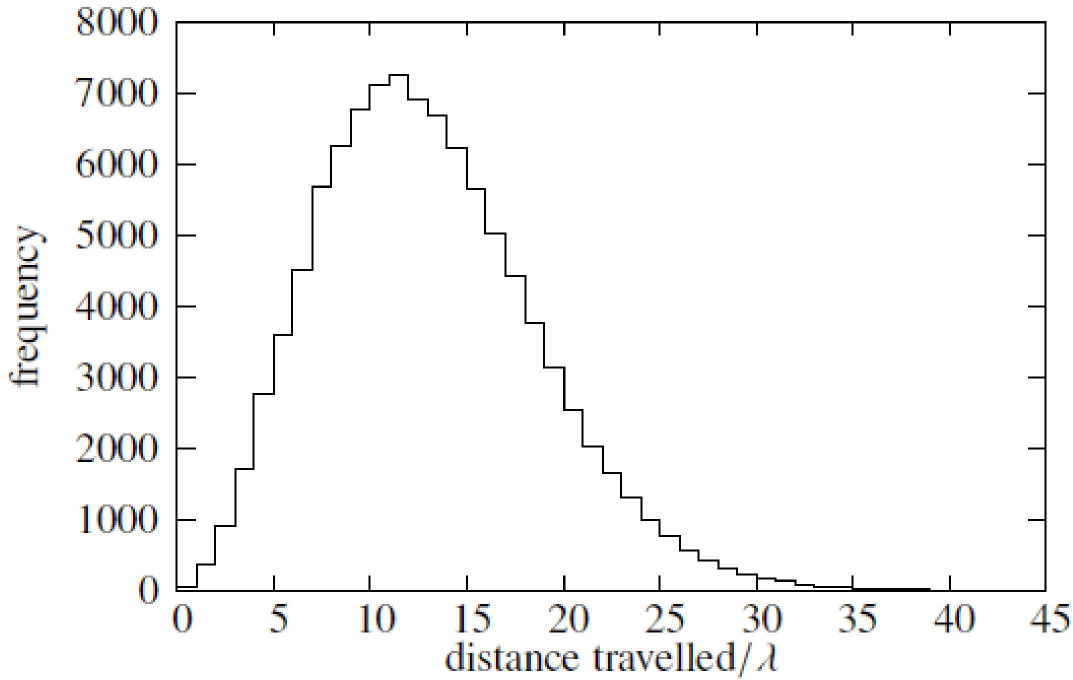
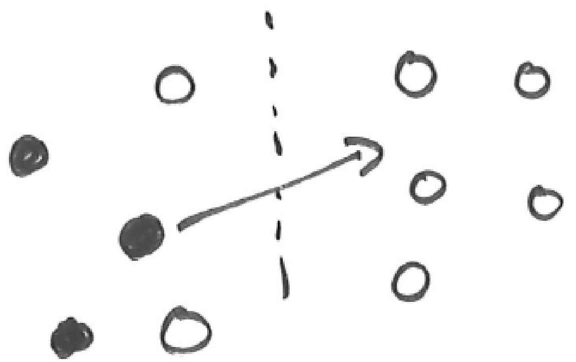


Figure 3.4 Frequency distribution of the distance travelled in 100 000 random walks, each of 100 steps, with the step-lengths themselves distributed according to an exponential distribution with mean λ. The mean distance travelled is 12.99λ, while the rms distance is 14.15λ and the maximum is 44.30λ.

Modelling Transport



black & white mix over time

movement of:

identity → diffusion

energy → thermal conductivity

momentum → viscosity

We can do simple models of all these... assume particles move in $\pm x$, $\pm y$, $\pm z$ <u>only</u>.

$1/6^{th}$ do each motion.

Ignore collisions - work in small Δt where pts cross line unimpeded

Diffusion

this defines Diffusion Coefficient $m^2 s^{-1}$

Fick's Law

$$\frac{dN}{dt} = - DA \frac{dn}{dx}$$

number flowing across dotted line /sec

Area flowing over

spatial density gradient

Let's use kinetic theory to study the same process.

Number flowing $L \to R$ $= \frac{1}{6} \underbrace{n(x-\lambda)}_{\text{density to left by } \lambda} \underbrace{A \bar{v} \Delta t}_{\text{volume that can cross in } \Delta t \text{ sec.}}$

1 in 6 go right way

Number flowing $R \to L$ $= \frac{1}{6} n(x+\lambda) A \bar{v} \Delta t$

so there's a net flow if the density is bigger on one side.

Net flow $L \to R$

$$\frac{dN}{\Delta t} = \frac{1}{6} \Big[\underbrace{n(x-\lambda)}_{n(x) - \frac{dn}{dx}\lambda} - \underbrace{n(x+\lambda)}_{n(x) + \frac{dn}{dx}\lambda} \Big] A \bar{v}$$

$$= \frac{1}{3} \lambda \bar{v} A \frac{dn}{dx}$$

$$\Rightarrow \boxed{D = 1/3 \, \lambda \bar{v}}$$

EG Evaporation from a test tube

$$\text{Flow rate} = -\tfrac{1}{3}\,\lambda\,\bar{v}\,A\,\frac{dn}{dx}$$

? dN/dt

Assume saturation density n_s just above surface; and zero at top

$$\frac{dn}{dx} = \frac{n_s}{h}$$

Ideal gas: $P_s = n_s k T_I$

$$= \frac{P_s}{h k T_I}$$

$$|\text{Flow rate}| = \frac{1}{3}\frac{\lambda \bar{v} A P_s}{h k T_I}$$

$$\text{Mass loss} = \frac{m_{mole}}{N_A}\frac{\lambda \bar{v} A P_s}{3 h k T_I}$$

$m_{mole} = m_{atom} N_A$

$$= \frac{m_{mole}}{R}\frac{\lambda \bar{v} A P_s}{3 h T_I}$$

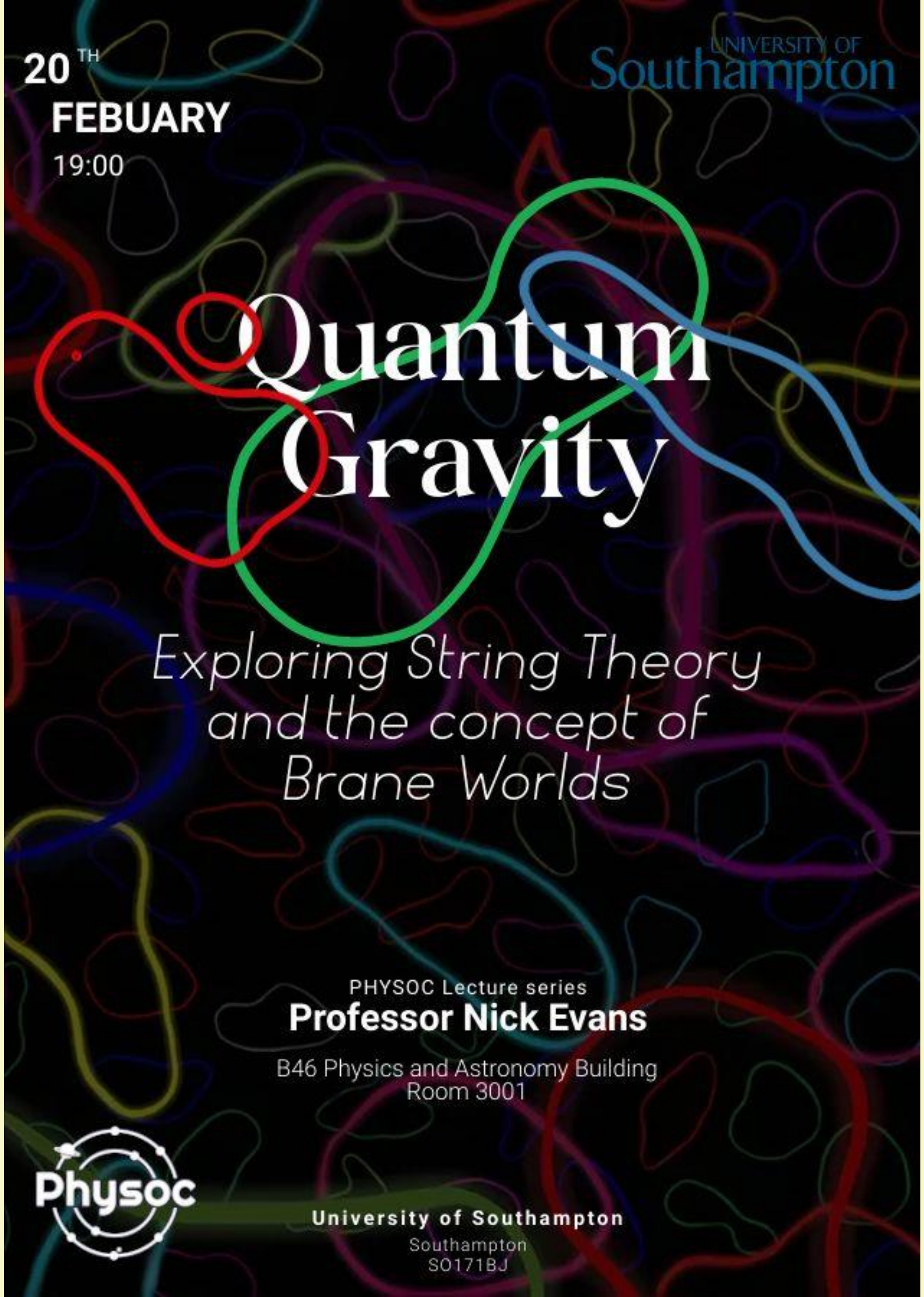
$\div$ density $\quad$ $$\text{Volume loss} = \frac{m_{mole}}{R}\frac{\lambda \bar{v} A P_s}{3 h T_I \rho}$$

$\div$ area $\quad$ $$\text{Height loss} = \frac{m_{mole}}{R}\frac{\lambda \bar{v} P_s}{3 h T_I \rho}$$

$T = 293\,K$; $P_s = 1710\,Nm^{-2}$; $\rho = 1000\,kg\,m^{-3}$

Is $h = 0.1\,m$, $\lambda = 10^{-7}\,m$, $\bar{v} = 650\,ms^{-1}$ (here weighs less than N_2)

$\Rightarrow$ 0.24 mm/day


20TH
FEBUARY
19:00
UNIVERSITY OF
Southampton
Quantum
Gravity
Exploring String Theory
and the concept of
Brane Worlds
PHYSOC Lecture series
Professor Nick Evans
B46 Physics and Astronomy Building
Room 3001
Physoc
University of Southampton
Southampton
SO171BJ