ANNOTATED TRANSLATIONS

PHYSICS MATERIALS

I turn to physics materials by first dealing with Base SI (85), Supplementary SI (86) and Derived SI (87) Units; the Derived Units have special names which have to be adopted intact because most of them were originally proper (personal) ones.

(85)	length	*obuwanvu*	
	mass	*obutole*	
	time	*ekiseera*	
	electric current	*omukulukuto omumeeme*	
	thermodynamic temperature	*obubugumye bunnajjululwabbugumu*	
	amount of substance	*obungi bw'omutole*	
	luminous intensity	*obunyiinyiitivu bw'ekitangaala*	
	metre	*mmita*	m
	kilogramme	*sseggramu*	kg
	second	*ssikonda*	s
	ampere	*ampere*	A
	kelvin	*kelvin*	K
	mole	*mmolo*	mol
	candela	*kasubbaawa*	cd

(86)	plane angle	*ensonda enseeteevu*
	radian	*ssekagulu rad*
	solid angle	*ensonda empulubavu*
	steradian	*ssempulubavu*

(87)	frequency	*omuddihano*	
	energy	*ekimulimuwazi*	
	force	*eryanyi*	
	power	*obuyinza*	
	pressure	*omunyigirizo*	
	electric charge	*obuwange obumeeme*	
	electric potential difference	*enjawulo y'obwekusike obumeeme*	
	electric resistance	*obugugubi obumeeme*	
	electric conductance	*obuyisaamu obumeeme*	
	electric capacitance	*obusobola obumeeme*	
	magnetic flux	*omuwanguko omunnamagineti*	
	inductance	*obufukuutirira*	
	magnetic flux density (magnetic induction)	*omufukuutiriro omunnamagneti*	
	luminous flux		
	illumination	*omutangaazo*	
	hertz	hertz	Hz

joule	joule	J
newton	newton	N
watt	watt	W
pascal	pascal	Pa
coulomb	coulomb	C
volt	volt	V
ohm	ohm	Ω
siemens	siemens	S
farad	farad	F
weber	weber	Wb
henry	henry	H
tesla	tesla	T
lumen	lumeni	lm
lux	luksi	lx

(88a) Text 5:

1.1 <u>Mechanics of a particle</u>

The essential physics involved in the mechanics of a particle is contained in *Newton's Second Law of Motion,* which may be considered equivalently as a fundamental postulate or as a definition of force and mass. For a single particle, the correct form of the law is:

$$\mathbf{F} = d\mathbf{p}/dt, \qquad (1\text{-}1)$$

where F is the total force acting on the particle and **p** is the *linear momentum* of the particle defined as follows: Let s be the curve traced by the particle in its motion, and **r** the radius vector from the origin to the particle. The vector can then be defined formally by the equation:

$$\mathbf{V} = d\mathbf{r}/dt, \qquad (1\text{-}2)$$

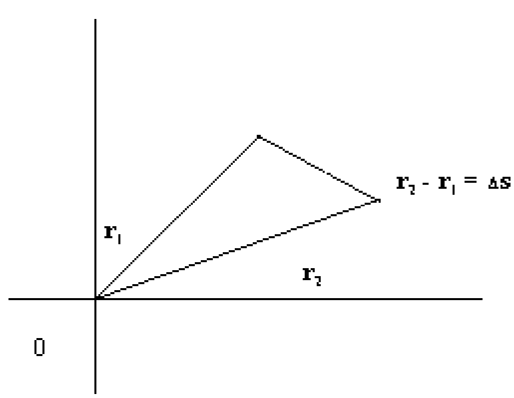
where the derivative is evaluated by the usual limiting process (cf. Fig. 1-1):

$$d\mathbf{r}/dt = \lim_{\Delta t \to 0} [(\mathbf{r}_2 - \mathbf{r}_1)/\Delta t] = \lim_{\Delta t \to 0} [\Delta \mathbf{s}/\Delta t] = d\mathbf{s}/dt$$

(This last form for the derivative explicitly indicates that **v** is tangent to the curve). Then the linear momentum **p** is defined in terms of the velocity as

$$\mathbf{p} = m\mathbf{v}, \qquad (1\text{-}3)$$

so that (1-1) can be written $\mathbf{F} = d(m\mathbf{v})/dt$. (1-4)



(1-4)

In most cases the mass of the particle is constant and Eq. (1.1) reduces to:

$$\mathbf{F} = m(d\mathbf{v}/dt) = m\mathbf{a} \qquad (1\text{-}5)$$

where **a** is called the acceleration of the particle as defined by

$$\mathbf{a} = d^2r/dt^2 \qquad (1\text{-}6)$$

Many of the important conclusions of mechanics can be expressed in the form of conservation theorems, which indicate under what conditions various mechanical quantities are constant in time. Eq. (1-1) directly furnishes the first of these, the *Conservation Theorem of the Linear Momentum of a Particle: If the total force,* **F**, *is zero, then* d**p**/dt = 0 *and the linear momentum p, is conserved.* The angular momentum of the particle about point O, denoted by **L** is defined as

$$\mathbf{L = r \times p} \qquad (1\text{-}7)$$

where **r** is the radius vector form 0 to the particle. Notice that the order of the factors is important. We now define the *moment of force or torque* about O as

$$\mathbf{N = r \times F} \qquad (1\text{-}8)$$

The equation analogous to (1-1) for **N** is obtained by forming the cross product of **r** with Eq. (1-4):

$$\mathbf{r \times F = N = r} \times d(m\mathbf{v})/dt \qquad (1\text{-}9)$$

Eq. (1-9) can be written in a different form by using the vector identity:

$$d(\mathbf{r} \times m\mathbf{v})/dt = \mathbf{v} \times m\mathbf{v} + \mathbf{r} \times d(m\mathbf{v})/dt$$

where the first term on the right obviously vanishes. In consequence of this identity Eq. (1-9) takes the form

$$\mathbf{N} = d(\mathbf{r} \times m\mathbf{v})/dt = d\mathbf{L}/dt. \qquad (1\text{-}10)$$

Note that both **N** and **L** depend upon the point O, about which the moments are taken.

As was the case for Eq. (1-1), the torque equation, (1-10), also yields an immediate conservation theorem, this time the *Conservation Theorem for the Angular Momentum of a Particle: If the total torque, N, is zero, then d**L**/dt = 0, and the angular momentum **L** is conserved.*

Next consider the work done by the external force . **F** upon the particle in going from point 1 to point 2. By definition this work is

$$W_{12} = \int_1^2 \mathbf{F} \cdot ds \qquad (1\text{-}11)$$

For constant mass (as will be assumed from now on unless otherwise specified), the integral in Eg. (1-11) reduces to

$$\int \mathbf{F} \cdot ds = m\int (dv/dt) \cdot v\, dt = m/2 \int (d(v^2)/dt)\, dt$$

and therefore

$$W_{12} = m(v_2^2 - v_1^2)/2 \qquad (1\text{-}12)$$

The scalar quantity mv2/2 is called the kinetic energy of the particle and is denoted by T, so that the work done is equal to the change in the kinetic energy:

$$W_{12} = T2 - T1 \qquad (1\text{-}13)$$

If the force field is such that the work W done around a closed orbit is zero, i.e.

$$\Leftarrow \mathbf{F} \cdot d\mathbf{s} = 0, \qquad (1\text{-}14)$$

then the force (and the system) is said to be conservative. Physically it is clear that a system cannot be conservative if friction or other dissipation forces are present, for **F.**d s due to friction is always positive and the integral cannot vanish. By Stokes' Theorem, the condition for conservative forces, Eq.(1-14), can be written:

= x **F** = 0,

and since the curl of a gradient always vanishes **F** must therefore be the gradient of some scalar:

F = - < V, (1-15)

where V is called the potential, or potential energy. The existence of V can be established without the use of theorems of vector calculus. If Eq. (1-14) holds, the work W12 must be independent of the path of integration between end points 1 and 2. It follows then that it must be possible to express W12 as the change in a quantity which depends only upon the position of the end points. This quantity may be designated by –V, so that for a differential path length we have the relation:

F . ds = -dV

or

F= -#v/ds,

which is equivalent to Eq. (1-15). Note that in Eq. (1-15) we can add to V any quantity constant in space, without affecting the results. *Hence, the zero level of V is arbitrary.* For a conservative system the work done by the forces is

$W_{12} - V_1 - V_2$ (1-16)

Combining Eq. (1-16) with Eq. (1-13) we have the result

$T_1 + V_1 = T_2 + V_2$. (1-17)

which states in symbols the *Energy Conservation Theorem for a particle: If the forces acting on a particle are conservative, then the total energy of the particle, T + V, is conserved.*

Goldstein (1950: 1-4)

[Notes on V.2.3.(88)]

"mechanics"; *mekanika*
"mechanic"; *makanika*
"postulate"; *-sab-;* "to request"; *ekisabo*
"define"; *ensalo;* "border"; *-salowaz-*
"linear"; *-nnamusittale*
"momentum"; *–vuumuul-;* "to move forward at full speed"; *venvuumuulo*
"curve"; *-got; olugote*
"vectorial"; *-kongojj-; -kongozzi*
"radius vector"; *ekikongozz ky'akagulu*
"evaluate"; *-wendowolol*
"moment"; *-nyool-;* "to twist"; *akanyoolo*
"conservation"; *-kuumirir-;* "to conserve"; *obukuumirizi*
"theorem"; *-kakas-;* "to prove"; *ekikakase*
"theory"; *-tetenkanyiriz-;* "to try hard to figure out"; *omutetenkanyalizo*
"torque"; *obunyoole*
"scalar"; *olupimo;* "scale"; *-nnalupimo*
"orbit, path"; *akakubo;* "path"; *olukubo*
"system"; *-yung-;* "to join"; *omuyungo*
"field"; *ekisaawe;* "field"; *omusaawe*

(88b) Translation of Text 5:

1-1 Mekanika w'akasirikitu. Omulamwa gwa fizika ali mu mekanika w'akasirikitu guli mu *Tteeka ly'Obwejjuluzi Ery'okubiri erya Newton,* erisobola okulowoozebwako nga ssemusingi oba ekisalowazo ky'eryanyi n'obutole. Kulwa akasirikitu ak'eddembe, ekikula ky'etteeka ekituufu kiri:

$$\mathbf{F} = d\mathbf{p}/dt, \qquad (1\text{-}1)$$

nga **F** lye lyanyi lyonna erikola ku kasirikitu era nga **p** ye envuumuulo nnamusittale y'akasirikitu esalowazibwa bweti: Leka s lube olukubo lw'akasirikitu akejjulula, era leka **r** kibe ekikongozzi ky'akagulu okuva ku nsibuko okutuuka ku kasirikitu. Embiro z'ekikongozzi zisalowazikira kikula mu kyenkano:

$$\mathbf{V} = d\mathbf{r}/dt, \qquad (1\text{-}2)$$

nga omuviisemu gumuwendowololwa mu masembereza aga bulijjo (cf. Fig. 1-1):

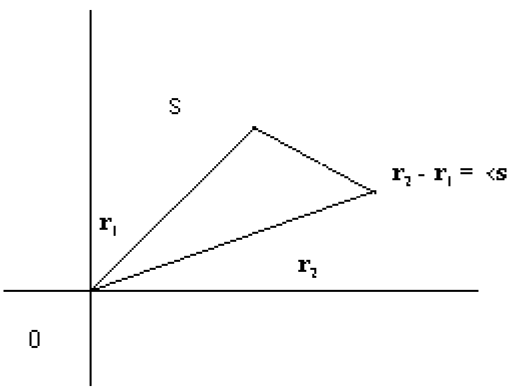
$d\mathbf{r}/dt = \lim [(\mathbf{r}_2 - \mathbf{r}_1)/$**<s/s/dt**

< t → 0 < t → 0

(Ekikula kino ekisembyeyo kulwa omuviisemu kyoleka lwatu nti v zikwata ku logote). Olwo envuumuulo nnamusittale p esalowalizibwa mu mbiro nga

$$\mathbf{p = mv}, \qquad \mathbf{(1\text{-}3)}$$

olwo (1-1)okuwandiikibwa F = d(mv)/dt.



(1-4)

Emirundi egisiga obutole bw'akasirikitu tebukyuka era Kyenka.(1-1) kizzika ku:

$$\mathbf{F = m(dv/dt) = ma} \qquad \mathbf{(1.5)} \quad \mathbf{(1\text{-}4)}$$

a wekiyitirwa omwanguyo gw'akasirikitu era ogusalowazibwa

$$\mathbf{a = d^2r/dt^2} \qquad \mathbf{(1\text{-}6)}$$

bifundikiro bya mekanika bingi ebikulu ebyasanguzikira mu kikula ky'ebikakase by'obukuumirizi ebiraga mbeera ki obungi bw'ekimekanika obutali bumu mwe butakyukira mu kiseera Kyenka.(1-1) kiwa butereevu emu zo, ***Ekikakase ky'obukumirizi kulwa Envuumuulo Nnamusittale y'Akasirikitu: Sssinga eryanyi lyonna,*** **F,** ***liba zzeero, olwo*** **dp/dt =** ***o era Envuumuulo nnamusittale p***β ***ekuumirirwa.***

Envuumuulo nnansonda ey'akasirikitu ku poyinti 0, erambibwa ne L esalowazibwa nga

$$\mathbf{L = r \times p} \qquad \mathbf{(1\text{-}7)}$$

r we kabeerera ekikongozzi ky'akagulu okuva ku 0 okutuuka ku kasirikitu. Labukira obutegeke bwa ffakita (emibazibwa). Kati tusalowaza obunyoole ku 0 nga

$$\mathbf{N = r \times F} \qquad \mathbf{(1\text{-}8)}$$

Ekyenkano ekyefaananyiriza (1-1) kulwa N kifunikira mu kuzimba omubaze gw'omulabba gwa r ne Kyenka (1-4):

$$r \times F = N = r \times d(mv)/dt \qquad (1\text{-}9)$$

Kyenka. (1-9) kiwandiikika mu kikula ekirala nga tukozesa obwenkanyinkanyi bwekikongozzi:

$$d(r \times mv)/dt = v \times mv + r \times d(mv)/dt$$

ekimiimo ekisooka ku ddyo we kibulira. Nga ekigoberezo ky'obwenkanyinkanyi buno Kyenka. (1-9) kitwala ekikula

$$N = d(r \times mv)/dt = dL/dt. \qquad (1\text{-}10)$$

Kenga nti N ne L zeesigama ku poyinti 0, obunyolo kwe butwalibwa. Nga bwe gwabadde kulwa Kyenka. (1-1), ekyenkano ky'obunyoole, (1-10), nakyo kivaamu mangu ekikakase ky'obukuumirizi, ku mulundi guno *Ekikakase ky'Obukuumirizi kulwa Envuumuulo Nnansonda ey'Akasirikitu: Ssinga obunyoole bwonna, N, buba zzeero, olwo* d*L*/dt *= 0, era mmomento nnansonda ekuumirirwa.* Kati lowooza ku mulimu ogukolebwa F ey'ebweru ku kasirikitu mu kugenda okuva ku poyinti 1 okutuuka ku poyinti 2. Mu busalowaze omulimu guno guli

$$W_{12} = \int_1^2 F \cdot ds \qquad (1\text{-}11)$$

Olwa obutole obutakyuka (nga bwe kijja okutwalibwa okuva kati okujjaako nga kyatuukirizibwa bulala) omulambirizo mu Kyenka. (1-11) guzzibwa ku

$$\int F \cdot ds = m\int (dv/dt) \cdot v\, dt = m/2 \int (d(v^2)/dt)\, dt$$

era nolwekyo

$$W_{12} = m(v_2^2 – v_1^2)/2 \qquad (1\text{-}12)$$

Obungi bunnalupimo mv^2 /2 buyitibwa ekimulimuwazi ky'obwejjuluzi bw'akasirikitu era bulambibwa na T, olwo omulimu ogukolebwa n'egwenkana enkyuka mu kimulimuwazi ky'obwejjuluzi

$$W_{12} = T2 – T1 \qquad (1\text{-}13)$$

Ssinga omusaawe gw'eryanyi guba nga omulimu W ogukolebwa ku lukubo oluggalewo guli zzeero, kwe kugamba,

$$\Leftarrow F \cdot ds = 0, \qquad (1\text{-}14)$$

olwo eryanyi (era n'omuyungo) ligambibwa okuba *ekkuumirizi.* Mu kifizika kitangaavu nti omuyugo tegusobola kuba mukuumirizi ssinga amanyi g'obukuubi oba amapunguuzi gabaawo, kubanga F.d s oguva ku bukuubi bulijjo mukkirizi era omulambirizo tegusobola kubula. Bwe tweyambisa Ekikakase kya Stokes, akakalu k'amaanyi amakuumirizi, Kyenka. (1-14), kasobola okuwandiikibwa:

$$= \times F = 0,$$

era olw'okuba nga amasadde g'omusuliko bulijjo gabula F kiteekwa okuba omusuliko gunnalupimo gundi:

$$F = - < V, \qquad (1\text{-}15)$$

V w'eyitirwa *amakusike, oba ekimulimuwazi ekikusike.* Okubeerawo kwa V kusobola okutebenkezebwa nga ebikakase by'embala y'ebikongozzi tebikozesebwa. Ssinga Kyenka.(1-14) kituufu omulimu guteekwa obuteesigama ku lukubo lw'okulambiriza wakkati w'enkomerero 1 ne 2. Olwo kigoberera nti kiteekwa okusoboka okwasanguza W12 nga enkyuka y'obungi obwesigama ku keesangiro k'enkomerero kwokka. Obungi buno tusobola okubulambisa –V ,olwo obuwanvu bw'olukubo lw'omwawulo bufunirwe oluganda:

$$F \cdot ds = -dV$$

oba

$$F_s = -\#V/ds,$$

ekyenkanankana Kyenka. (1-15). Kenga nti mu Kyenka.(1-15) ku V tusobola okuggatako obungi bwonna obutakyuka mu bbanga nga tewali kikyuka. Nolwenkyo, *eddaala zzeero erya V lya kyeyagalire.* Olwa omuyungo omukuumirizi omulimu ogukolebwa amaanyi guli.

$$W_{12} = V_1 - V_2 \qquad (1\text{-}16)$$

Bwe tugatta Kyenka. (1-16) ne Kyenka (1-13) tufunamu

$$T_1 + V_1 = T_2 + V_2. \qquad (1\text{-}17)$$

ekigamba mu bubonero

Ekikakase ky'obukuumirizi bw'Ekimulimuwazi olw'Akasirikitu: Ssinga amaanyi agakola ku kasirikitu gaba amakuumirizi, olwo ekimulimuwazi kyonna eky'akasirikitu, T + V, kikuumirirwa.

Translated from Goldstein (1950: (1-4)

(89) Text 6:

<u>The de Broglie Relation</u>

In the previous chapter we have seen that electrons and other subatomic particles sometimes exhibit properties similar to those commonly associated with classical waves so that, for example, electrons of the appropriate energy are diffracted by crystals in a manner similar to that originally observed in the case of x-rays. Morever, the energy and momentum of a free particle can be expressed in terms of the angular frequency and wave vector of the associated plane wave by the de Broglie relations (1.10). In this chapter we shall consider one-dimensional examples only and extend our treatment to three-dimensional systems in the next chapter. In one dimension the wave vector and momentum of a particle can be treated as scalars so that the de Broglie relations can be written as

(2-1)

We shall use these and the properties of classical waves to set up a wave equation, known as the *Schrödinger wave equation,* appropriate to these matter waves, and when we solve this equation for the case of particles that are not free but move in a potential well, we shall find that solutions are only possible for particular discrete values of the total energy. We shall apply this theory to a number of examples and compare the resulting energy levels with experimental results.

[Notes on V .2.3(89)]

"electron"; *elektroni*
"atom"; *atomu*
"classical"; *ennono; -nnannono*
"diffract"; *-wugul-*
"crystal"; *kristo*
"x-ray"; *akagulu-x*
"frequency"; *omuddirihhano*
"plane"; *-seeteevu;* "flat"; *"oluseeteevu*
"pontential well"; *oluzzi; olukusike*

"discrete"; *-ekusifu*
"dimension"; *olupimiro*

(89b) <u>Translation:</u>

Wansi w'omutwe oguwedde tulabye nti elektroni n'obusirikitu bunnaatomulukka oluusi bwolesa emize egifaanana n'egyo egitera okunywanyizibwa n'mayengo gannannono nga, okugeza, elektroni z'ekimulimuwazi ekisaanira ziwugulibwa kristo mu ngeri efaanana kwe eyo eyakengebwa mu kusooka ku bugulu-x. Ate era ekimulimuwazi ne envuumuulo ey'akasirikitu ak'eddembe bisobola okwasangulizibwa mu muddirihhano gunnansonda n'ekikongozzi eky'ejjengo ly'oluseeteevu erigwanira nga tukozesa ebigandawazo bya de Broglie (1.10). Wansi w'omutwe guno tujja kuleeta ebyokulabirako binnalupimiro -lumu byokka era tujja kweyongera tutuuke ku miyungo ginnampimiro -ssatu wansi w'omutwe oguddirira. Mu lupimiro olumu ekikongozzi ky'ejjengo n'envuumuulo y'akasirikitu bisobola okutwalibwa nga obungi bunnalupimo: n'olwekyo ebigandawazo bya de Broglie bisobola okuwandiikibwa nga

E = ⇓ω   p = "k   (2.1)

Tujja kukozesa bino n'emize gy'amayengo gannannono tuteekewo ekyenkano ky'ejjengo ekimanyiddwa nga *ekyenkano ky'ejjengo kya Schrödinger* ekikwatagana "n'amayengo ga nnamutole," era bwe tumerengula ekyenkano kino nga obusirikitu si bwa ddembe wabula nga bwejjulula mu luzzi olukusike, tujja kuzuula nga ebimerengulo bisobokera kulwa miwendo g'ekimulimuwazi kyonna emyekusifu. Tujja kukozesa omutetenkanyirizo guno ku byokulabirako ebiwera era tugeraageranye amadaala g'ekimulimuwazi agavaamu n'ebiva mu kugezesa.

Translated from Rae (1986: 15)