

GYAN VIGYAN SARITA: शिक्षा

A non-remunerative, non-commercial and non-political initiative to
Democratize Education as a Personal Social Responsibility (PSR)

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Special Issue: March'14 Every Year is commemorated as Pi ($\pi=3.14$) Day

BEST WISHES
FOR YOUR FINAL EXAMS

MAY YOU COME THROUGH
WITH FLYING COLOURS



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Aim for the Best, but...



Online Mentoring From Texas

Equipments at Mentoring Center

1. Compatible Desk-/Lap-top
2. WebCam
3. Headset with Microphone
4. Wacom Tablet Pen

AND

Broadband-Internet Connection:
Minimum Bandwidth: 8 Mbps and Monthly Data Capacity: (1xN) GB ;
 Here, N= No of Hours of Monthly

Conceptual Representation
 of
Interactive Online Mentoring Sessions (IOMS)
An Initiative To Bridge Gap between
Passionate Teachers
 and
Desperate Students
A Selfless Endeavour
 to
Democratize Education
 with a sense of
Personal Social Responsibility (PSR)



An Ideal Smart Training Center
(If we can afford it for all)

Equipments at Learning Center

1. Compatible Desk-/Lap-top
2. WebCam
3. Speakers
4. USB Microphone
5. Overhead Projector.
6. Wacom Tablet Pen with Wireless Accessory
7. UPS (For Continuous Power Supply to computer, internet modem and L&F)

AND

Broadband-Internet Connection: **Min. 8 Mbps and (1xN) GB monthly data capacity; N= No of Hours of Monthly sessions**



WebEx® Whiteboard – a Fully Shared Space between Students and Mentor using Wacom Tablet (Interactive Online Mentoring)



Primitive Mentoring-cum-Learning Centre (Demo)

Important Links

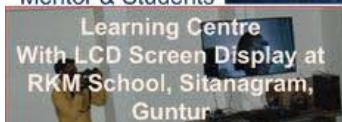
1. Good Internet Connectivity (Preferably-Wired Broadband Connection, or 4 G Mobile)- Exclusive
2. Subject-wise Coordinator for Each Session to Bridge Learning Gaps between Mentor & Students



Special Features

1. Free and Open to all to adopt, Modify, Change, Use or Take-away
2. Welcomes participation, promotion and facilitation on Zero-Fund-Zero-Asset (ZFZA) basis
3. More details on Technological and Operational – please write on <http://www.gyanvigyansarita.in/contact/>

subhashjoshi2107@gmail.com



Learning Centre With LCD Screen Display at RKM School, Sitanagram, Guntur

We start with what is available in ground;
Aim at best Grooming for Competence Building
Unprivileged;
Welcome better and more economical, but functionally
suitable for IOMS, setup to reach Unprivileged Students
: Spiritually Democratize Education.



Learning Centre With Projector Display (Widely Practiced)

... start, without loosing time, with whatever is available.



संपादकीय

पाई (π) दिवस

अरस्तु यूनानी दार्शनिक थे। वह प्लेटो के शिष्य और सिकंदर के गुरु थे। उनका कहना था कि मनुष्य प्राकृतिक रूप से ज्ञान की इच्छा रखता है।

पाई दिवस गणित और विज्ञान प्रेमियों के लिये बहुत कुछ जानने का दिन होता है। सभी इसके गुणों को जानने, इसके बारे में हुयी अबतक की खोजों को एकत्र करने, और सब मिलकर इसके रहस्यमयी प्रकृति को समझने की कोशिश करते हैं।

हर विद्यार्थी अपनी स्कूली शिक्षा के दिनों से ही पाई के बारे में जान जाता है। उच्चतर कक्षाओं में तो गणित, भौतिकी और अभियांत्रिकी के सूत्र प्रायः पाई को संजोये रहते हैं। हर विकास का कदम इस संख्या के साथ लेकर चलता है।

पाई का उपयोग ज्यामिती (Geometry) में एक अनुपात के रूप में होता है। पाई की शुरुआत ज्यामिती से मानी जाती है। किसी भी वृत्त की परिधि और उसके व्यास के अनुपात को पाई का नाम दिया गया है। यह ऐसी संख्या है जिसके मान को किसी भिन्न के रूप में नहीं लिखा जा सकता है। गणितज्ञों ने पाई के मान को भिन्न भिन्न तरीके से निकालने का प्रयास किया है, लेकिन सभी का अंतिम निष्कर्ष यही है कि इस संख्या का कोई निश्चित मान नहीं है। यह एक अपरिमेय संख्या है।

पाई का सबसे पहले उपयोग वेल्श के गणितज्ञ विलियम जोन्स ने 1706 में अपनी गणितीय पुस्तक *Synopsis Palmariorum Matheseos* में किया था। उन्होंने परिधि के लिये ग्रीक शब्द $\pi\epsilon\rho\acute{\iota}\mu\epsilon\tau\rho\omicron\varsigma$ के पहले अक्षर π को अपनाया। भारतीय गणितज्ञ ब्रह्मगुप्त ने 10 के वर्गमूल को पाई का मान बताया। यूनानी गणितज्ञ आर्कमिडीज ने पाई के मान को $\frac{223}{71}$ और $\frac{22}{7}$ के बीच होना पाया। न्यूटन ने एक सीरिज का प्रयोग करके पाई का मान निकाला। अबतक ज्ञात पाई के मान की एक विशेषता यह है कि चाहें हम दशमलव के कितने ही अंक तक मान निकालें उसमें कोई पैटर्न नहीं बनता है।

जर्मन गणितज्ञ लेबनिज (Gottfried Wilhelm Leibniz) ने पाई के मान के लिये निम्न सीरिज विकसित किया।

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \dots$$

इसे माधव-लेबनिज सिरीज भी कहते हैं। माधव हिंदुस्तान के 14वीं शताब्दी के गणितज्ञ थे।

14 मार्च का दिन विज्ञान के इतिहास में एक अन्य घटना के कारण भी महत्वपूर्ण है। महान विचारक और असाधारण प्रतिभा के धनी आइंस्टीन का जन्म 14 मार्च 1879 को तत्कालीन जर्मन साम्राज्य का हिस्सा रहे बुटेमवर्ग के एक यहूदी परिवार में हुआ था। इस दिन का महत्व कितना है, यह जानने के लिये केवल आइंस्टीन शब्द की जानकारी ही पर्याप्त है। आइंस्टीन शब्द वर्तमान में बुद्धिमत्ता का प्रतीक है। कहा तो यहां तक जाता है कि ऐसा विद्वान होना अब असंभव है।

पाई एक अपरिमेय संख्या है। अपरिमेय संख्या वह संख्या होती है जिसका मान न तो निश्चित होता है और न ही आवर्ती। जैसे $\frac{1}{2}$ का मान 0.5 होता है। यह एक निश्चित मान है। दूसरी भिन्नात्मक संख्या $\frac{1}{3}$ है। इसका मान 0.333333... निश्चित नहीं होता है। यह

एक आवर्ती संख्या कहलाती है। $\frac{1}{2}$ और $\frac{1}{3}$ जैसी संख्याओं को गणित की भाषा में परिमेय संख्या कहते हैं, अर्थात् परिमेय संख्याएँ वह हैं जिनका मान या तो निश्चित होता है अथवा वे आवर्ती होती हैं। परंतु पाई का मान न तो आवर्ती होता है और न ही निश्चित होता है। इसलिये इसे अपरिमेय संख्या कहते हैं।

पाई का मान $\frac{22}{7}$ से कम होता है। पाई का मान निकालने के लिये बहुत से गणितज्ञों - आर्यभट्ट, आर्कमिडीज, लियुह्यु, विलियम जोन्स, आदि ने काम किया। हम पाई को समझने के लिये आसान भाषा में कह सकते हैं कि यदि किसी वृत्त का व्यास 1 हो तो उसकी परिधि पाई के बराबर होगी।

कुछ मिस्र विद्वानों का मत है कि गीजा के महान पिरामिड बनाने वालों को पाई का ज्ञान था। उनका तर्क है कि 2586 से 2566 ई0 पूर्व

बने गीजा के पिरामिड का परिमाण 1760 क्यूबिट और उंचाई 280 क्यूबिट थी। क्यूबिट एक हाथ की लंबाई के बराबर की इकाई है। इस अनुपात $\frac{1760}{280}$ का मान लगभग 6.2857 आता है जो पाई के मान का दुगुना है। लेकिन यह संयोग के अलावा कुछ और नहीं हो सकता है क्योंकि इसका कोई आधिकारिक प्रमाण उपलब्ध नहीं है।

भारत में ईसापूर्व 600 में पाई के मान को शुल्ब सूत्रों में $(9785/5568)^2$, लगभग 3.088 लिखा गया है। आर्यभट्ट ने इसका मान 3.1416 निकाला था। उन्होंने इस मान को निकालने के लिये एक सूत्र का प्रयोग किया था-

चतुराधिकं शतमष्टगुणं द्वाषष्टिस्तथा सहस्राणाम् ।

अयुतद्वयस्य विष्कम्भस्य आसन्नौ वृत्तपरिणाहः ॥

अर्थात् 100 में 4 जोड़ें, आठ से गुणा करें, फिर 62000 जोड़ें। इस नियम से 20000 परिधि के एक वृत्त का व्यास ज्ञात किया जा सकता है:
$$\frac{(100 + 4) \times 8 + 62000}{20000} = 3.1416$$

एक अन्य भारतीय गणितज्ञ शंकर वर्मन ने सद्रत्नमाला में पाई का मान इकतीस दशमलव स्थानों तक 3.1415926535897932384626433832795 निकाला था।

29 मार्च 2015 को भारत के राजस्थान प्रांत के मोहचा गांव के राजवीर मीणा ने पाई का दशमलव के बाद 70 हजार अंकों तक का मान 9 घंटे 27 मिनट में सुनाकर गिनिज बुक में अपना नाम दर्ज कराया था। यह कार्य पाई के सही मान जानने के प्रति लोगों का लगाव, झुकाव और दीवानापन दिखाता है।

आजकल कोणों के मानों को रेडियन में लिखने की परंपरा ने पाई को त्रिकोणमिती (Trigonometry) का अभिन्न अंग बना दिया है। पाई रेडियन का मान 180 अंश के बराबर अथवा दो समकोणों के मान के बराबर लिखा जाता है। पाई के उपयोग का सबसे बड़ा उदाहरण बफोन की सुई (Buffon's Needle problem) का प्रश्न है।

जापान के एक इंजिनियर ने पाई का मान निकालने के लिये लगातार 90 दिनों तक जी तोड़ मेहनत की पर उसकी गणना खत्म नहीं हुयी। इस बीच उसने दशमलव के बाद पांच हजार अरब अंकों तक मान निकाला।

पाई का संख्यात्मक मान लगभग 3.14 होता है। इसीलिये 3/14 यानि मार्च 14 को हर साल पाई दिवस मनाते हैं। पाई दिवस का विचार सर्वप्रथम 1989 में लेरी शौ (Lary shaw) ने प्रतिपादित किया था। वर्ष 2009 में यूएस0 हाउस आफ रेप्रेजेंटेटिव्स ने 14 मार्च की तारीख को पाई दिवस के रूप में मनाने का निर्णय किया था। तब से आजतक 14 मार्च को लगातार पाई दिवस के रूप में मनाया जा रहा है। इससे मिलती जुलती एक और तारीख 22 जुलाई यानि 22/7 है। इसे पाई एप्रॉक्सिमेशन दिवस के रूप में मनाया जाता है।

पाई के प्रति झुकाव स्विस गणितज्ञ लियोनार्ड यूलर द्वारा विकसित $e^{i\pi} + 1 = 0$ समीकरण के बाद और बढ़ गया है। यूलर के इस समीकरण को गणित का सुंदरतम समीकरण कहा जाता है। e, i, π तीनों ही अपरिमेय संख्यायें (irrational numbers) हैं फिर भी ये मिलकर एक परिमेय संख्या -1 के बराबर मान देती हैं। e को यूलर अंक कहते हैं। इसका मान 2 और 3 के बीच होता है। i एक काल्पनिक संख्या है जिसका मान $\sqrt{-1}$ होता है।

पाई के मान की एक झलक:

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3.141592653589793238462643383279502884197169399375105
8209749445923078164062862089986280348253421170879821
48086813282306647093844609590582231725359408128481117
45028410270193852110555964462294895493038196442881097
56659334461284756482337867831652712019091486488669234
60348610454326648213393607260249141273724587008606318
58817488152092096282925409171536436789259036001133053
05488204665213841469519415116094330872703637595919530
92186117381932611793105118548074462379962749567531885
75272489122793818301194912983367336244065664308602139
49483952247371907021798609437027705392171762931767523
84674818467669405132000568127145263560827785771342757
7896091736371787214684409012249534301465498537105079
22796892589235420199561121290219608640344181598136297
74771309960518707211349999998372978049951059731752816
09631859802445945534690830264252230825334466850352619
3118817101000313783875288658753208381420617177669147
3035982534904287554687311595628638823537875937519577
818577805321712268066130019278766111959092164201989....
```

हम विश्वास कर सकते हैं कि नजदीक भविष्य में पाई के मान का रहस्य हल होगा। हमारे गणितज्ञ इसके मान की संरचना को समझेंगे और इससे संबंधित नयी नयी जानकारीयां खोजेंगे। डेनियल टमेट (Daniel Tammet) ने अपनी पुस्तक Thinking in Numbers: How Maths Illuminates Our Lives में बहुत ही खूबसूरत तरीके से पाई के मान का वर्णन किया है - एक घंटी समय नहीं बता सकती है, लेकिन बारह बार बजाकर यह समझा जा सकता है कि 12 बजे हैं। ठीक उसी प्रकार से एक व्यक्ति अनंत संख्याओं की गणना नहीं कर

सकता है, फिर भी वह गणना करते करते उसे पाई कह सकता है। (A bell cannot tell time, but it can be moved in just such a way as to say twelve o'clock – similarly, a man cannot

calculate infinite numbers, but he can be moved in just such a way as to say pi.)

सभी गणित और भौतिकी प्रेमियों को पाई दिवस की शुभकामनायें।

—00—

OUR MENTORING PHILOSOPHY: Mentoring is not teaching, neither tuition nor coaching. It is an activity driven by passion, and commerce has no place in it. In this effort is to caution students that -

- This place is not where they will be taught how to score marks and get higher ranks, but to conceptualize and visualize subject matter in their real life so that it becomes intuitive.
- This place is not to aim at solutions but inculcate competence to analyze a problem and evolve solution.
- This place does not extend selective and personalized attention, rather an opportunity to become a part of which is focused on learning and problem solving ability collectively.
- This place provides an opportunity to find students above and below one's own level of learning. Thus students develop not in isolation but learn from better ones and associate in problem solving to those who need help. This group dynamics while create a team spirit, an essential attribute of personality, while one learns more by teaching others.
- This place has strategically chosen Online Mentoring, so that those who are unprivileged can gather at one point and those who can facilitate learning of such students by creating, necessary IT setup. Aseparate [Mentor's Manual](#) is being developed to support the cause.

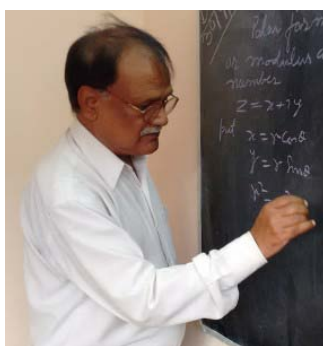
We are implementing this philosophy through [Online Mentoring](#)

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हमारापंचवर्षीयप्रवास



Start: June-2012



April-2015



June-2016.....

पारम्परिक शैक्षणिक मार्दर्शन से प्रारम्भ कर आज हम तकनीकी-विकास के सहारे मूलभूत प्रासंगिकता को आगे बढ़ने में संलग्न हैं...

यह प्रयास अपने सामाजिक कर्तव्य के प्रति सहजविनीत आग्रह है; कृपया इस पर विचार करें.

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An Appeal: Gyan Vigyan Sarita

A non-organizational initiative of a small set of Co-passionate Persons

Philosophy: Personal Social Responsibility (PSR)

Objective: Groom competence to Compete among unprivileged children from 9th-12th in Maths and Physics, leading to IIT-JEE.

Financial Model: Zero-&-Fund-Zero-Asset (ZFZA). It calls for promoters and facilitators to provide infrastructure for use to the extent they feel it is neither abused nor there is a breach of trust. And, reimbursement of operational expenses to the participators

Operation:

- a. **Mode:** Online since July'16, using Google Hangouts, a free we-conferencing S/w, with connectivity upto 15 nodes.
- b. **Participation:** Voluntary and Non-remunerative, Non-Commercial and Non-Political

Involvement:

- a. **As Promoter –**
 - i. Initiate a Learning Center,
 - ii. Sponsor a Mentor who is willing to join on certain terms,
 - iii. sponsor cost of operation and up-gradation of infrastructure to voluntary mentors,
 - iv. Sponsor Website.
- b. **As Facilitator –**
 - i. Provide space and infrastructure for **Online Mentoring Sessions (OMS)**, which is generally available, with a marginal add-on,
 - ii. Garner support of elite persons to act as coordinators at a Learning Centre.
- c. **As Participator –**
 - i. As a Mentor,
 - ii. As Coordinator,
 - iii. As Editor and or contributor of thought provoking articles for e-Bulletin, which are relevant to the initiative, and make it more purposeful and reachable to the target audience.
 - iv. As author of Chapters for Mentors' Manual, being uploaded as a Free Web Resource,
 - v. Anything else that you feel can add value to the mission and make it more purposeful.
 - vi. *Anything else that you consider to make this initiative to become more effective.*

Background: The initiative had its offing in May'12, when its coordinator, a power engineer by profession, soon after submission of Ph.D. Thesis in April'12, at IIT Roorkee, at the age of 61 years, decided to mentor unprivileged students.

SARTHAK PRAYASH, a Ghaziabad based NGO, warmly accepted the proposition and created a facility to mentor students from 8+ to prepare in mathematics and physics and prepare them for engineering entrance tests. They warmly reciprocated and created a class room.

Experience in this selfless social work were used to navigate across without losing focus. He was associated with SUBODH FOUNDATION from Sept'15 to Sept'16 during which he published a monthly e-Bulletin **SUBODH-पत्रिका** to create visibility across persons who could make a difference.

In Sept'16, post transition, the mission has been continued as a non-organizational entity **Gyan Vigyan Sarita**, with a set of Four persons, including retired **Prof. SB Dhar**, Alumnus-IIT Kanpur, a middle aged **Shri Shailendra Parolkar**, Alumnus-IIT Kharagpur, settled at Texas, US and **Smt. Kumud Bala**, Retired Principal, Govt. School Haryana. Earlier, they were complementing the OMS. While, the initiative survived transition, a website: <http://gyanvigyansarita.in> has been launched. It contains under its **Menu: Publication>e-Bulletins**, and **>Mentors' Manual**. You may like to read them.

Actions Requested: May please like to ponder upon this initiative. **Queries**, if any, are heartily welcome. We would welcome your collective complementing in any of the areas listed at **Involvement**, above, to make the mission more purposeful and reachable to target children.



IOMS : Way Forward

"IOMS: Opportunities and Challenges", was elaborated in the e-bulletin's issue dt 1st Feb'18. It has been a thrilling journey and a satisfying experience to reach a stage in nearly Six years where we have to request aspiring schools and organizations to allow us time of stabilization of **Interactive Online Mentoring Sessions (IOMS)**. This stabilization is aimed at the schools whom we have committed to hold IOMS. Level of commitment of Gyan Vigyan Sarita by way its nature and characteristic is non-organizational, non-remunerative, non-commercial, and non-political, and driven by a small set of co-passionate persons with a sense of Personal Social Responsibility (PSR). Its financial model is Zero-Fund-&Zero-Asset (ZFZA) and that has made its journey tougher and growing slowly. This slow growth and taking a pause for stabilization is definitely unwarranted, in a state of education prevalent in the country. We stand to appear in the witness box in court of elite citizens and policy makers to place our perspective for consideration and pass judgement, if taking pause is as insincerity.

Gyan Vigyan Sarita believes that it is its duty to build aspiration among unprivileged section of society, create dream and extend finger holding in the process. This is more true to children, who have potential to change course of destiny of the nation. Despite, it is wary of the fact creating hopes and letting them abort is an act of brutal betrayal towards those who have learned to live in a state of hopelessness.

A Torch Bearer: In the initial phase of this mission, which started in a Chalk-N-Talk mode, many students joined. But, Rohit, the only student, from one of the most humble background carried through the mentoring upto Class 12th. He did not succeed in cracking IIT-JEE, but he maintained the connectivity with his mentors even after joining engineering at one of the private colleges. A few days ago, he informed his success in First Semester examination with 81.5%, which by any scale is commendable, specially in his context. Glitter in his eyes was conveying that he has been able to make best of learning in this initiative, last phase of which was in Online Mentoring mode, has helped him to perform much better than many others growing in better environment. This narration is essential to bring home the contention that success in education is multi-dimensional process of self-carving which is slow, gradual and requires perseverance. It can't be achieved quickly through shortcuts.

Efforts: Need of efforts and resources in educational transformation are mammoth. This reduces mightiest government to omnipotent organizations to pigmies. But, can this be allowed for society to remain complacent and feel helpless in affecting necessary change. It requires a need of realization of PSR at the core of heart of individuals and each elite carries out an honest SWOT analysis, to identify ones boundaries. Once these boundaries are defined, next step is about exploring individuals

and organizations with matching. This has to be followed with collaborating across to create a homogenous purpose-driven matrix that coexists. This is precisely the operational strategy of the initiative to deploy skill gained. Jig-Saw-Puzzles is not a childhood game, it is a real life proposition of coexistence. In this pursuit commitment is to the target students. None else, howsoever mighty may be, is above a single student who is deprived of educational opportunity.

Critical Factor in IOMS: Three basic ingredients of IOMS are- **a)** Passionate mentors, **b)** Schools or social organizations capable of facilitating learning of cluster of target students, and **c)** ICT Infrastructure. A stage to seek time for stabilization of IOMS needs critical examination of the bottleneck; and this is found to be technology. ICT technology promises bandwidth as high as @ 100 Mbps in metro and 500 Kbps in rural areas and isolated places, where wired connections are available. Interactive nature of IOMS calls for extensive data transfer of video, audio and whiteboard collaboration across nodes. It involves extensive whiteboard writing, One at a time, either Mentor or One of the learning node. Improved algorithms of data transfer and processing of incremental change are assured by providers of cloud platform for Virtual Classes. But, experience in IOMS is yet to reach a satisfactory level of seamless streaming. Realization of real benefits of IOMS necessitates putting in place technological improvement. Unless this happens benefit of IOMS, as envisaged, would scale-down drastically. This in turn would create unsustainable pressure on mentors. Moreover, in an environment where sense of PSR is yet to become an acceptable norm, number of children, deprived of opportunity to garner competence, would keep swelling. Taking an hypothetical proposition that a few passionate

mentors are able to selflessly dedicate themselves since morning till night, it will widen the window of session-hours of IOMS to an extent that it would stretch into unsafe hours for students and as well as schools opting for it.

Keeping videos active, across all participants, and audio and whiteboard interaction to a group, one student at a time is essential to maintain a vibrant participation of all students. In absence of this experience of IOMS reduces to offline videos. Any advice to manage streaming by putting off videos is nothing but a crisis management and not an appropriate technological solution.

In present scenario where competitive cloud platforms are available, we wish respect claim of each. They claim to offer seamless streaming of audio-video-whiteboard interaction across multiple nodes at a bandwidth of even few tens of kbps per node. It is claimed to be achieved through a result of right combination of data-compression, processing and data-communication. Yet, it is distressing that not a single platform, among those tested, has been able to demonstrate performance up to satisfaction of IOMS across even Three nodes. In such a scenario any claim of multi-classroom environment is a hoax call. This challenge is open to all the vendors and we would heartily welcome them to demonstrate their claim. If this happen, it is assured that it would be breaking ice for a new scenario which promises IOMS, in its variants. This is the only option to connect desperate teachers to students, diffusing all kinds of boundaries.

Making Right Technology Choice: Technology, in ICT, is a domain of specialists. Despite GUI based interactive tools available on the web, making a right choice requires experimenting with each platform having a financial implication. This requires a degree of familiarization with technology and malleability to sail into each. *Generally persons passionate to teach are able to surf due to their urge, but it is at the cost of their mentoring time, needed by students.* This requires forums which make candid evaluation of the available platform of virtual class room, and make them available freely to mentors. We are yet to come across one such dissemination, and would gratefully welcome input on this.

Is IOMS an Art?: Interactive Online Mentoring, is a beautiful combinations of technology, art and passion. Keeping students involved in pursuit of quality learning, which has no shortcuts is not an cake walk. Technology establishes an environment of connectivity and communication. But, involving

students into a vibrant interaction, motivate them to carryover of learning after the session, and involvement of local teacher, as coordinators, to become active participant in IOMS involves combination of psychology, art of human interaction and technological support to overcome seamless streaming issues. Degree of involvement in IOMS cannot be imposed, unless one feels an urge about it. This urge is nothing but manifestation of an individual's passion. Pursuit of this kind of passion by individuals is very good and laudable. But, unless this passion is driven to catalyze the environment where more elite are awakened to complement collectively with a sense of PSR, the job is half-done; this has to be made to happen only with the missionary spirit in the pursuit.

Limiting Number of Nodes: IOMS, by virtue of its philosophy, is just not either for self-contentment, or imparting education as ज्ञान दान. It is about creating an environment where more and more elite persons come forward in making education a thought provoking process, among target students, leading to competence of solving problems which are economical, sustainable and promotes coexistence. Involvement of mentor in such a pursuit cannot be in a broadcast mode. In this headcount of attendees is of least importance; what matters is the incremental transformation in each participant in progressive session. It, therefore, envisages not more than Five to Six learning centres concurrently addressed by a mentor. This has Five perspectives – **a)** it will act as a retardant in driving IOMS towards commercialization, **b)** create a motivation for more elite persons to contribute in the social reform through education, **c)** it should not be a big target for service providers to ensure seamless streaming, across nodes, in IOMS, the most critical factor, **d)** it should be possible for a mentor, equipped with a wide projection screen, to create and maintain vibrant interaction among participant, and **e)** create a panel of mentors which will help in maintaining continuity, consistency and diversity. Such a scenario of collective complementing would compound synergy, which otherwise exponentially discounts when players in such an initiative compete with each other.

Conclave on IOMS: Education is a sector which validates the phrase “A stitch in time saves nine”. It needs little if actions are timely and properly initiated and pursued, while its returns are immense for nation in the form of a stable and sustainable growth. There are many organizations, individuals and philanthropists addressing the educational

needs of masses. Each of them has grown and learned its hard way in discrete environment at different times. However, mostly they are unaware of each other or in a state of non-communication. Needs of educational reforms are mammoth and multidimensional. It needs a collective and complementary approach. Maintaining sovereignty in operation is a matter of choice, nevertheless mutual enrichment is needed in furtherance of this cause from time to time.

In view of this it is essential to create a platform for all, who struggle to achieve social justice through on-line affordable education to vulnerable sections of society. This will help to create a synergy of persons who are contributing for this cause and to induct a cadre of competent teachers who are having passion for this cause. This can be achieved by initiating a conclave which would create a win-win situation for all players as briefly outlined below.

NGO: They have their own channels of resources, but they lack passionate persons in furtherance of its objectives. This vitiates the whole scenario leading to a bad name for NGOs. Collectively complementing of efforts of the initiative by NGOs would find a proper utilization of precious resources and earn credibility.

Schools and Institutions: Paucity of passionate teachers with growing parallel and highly commercialized education needs no elaboration. Collectively complementing of efforts in this initiative, would only help them to improve performance of their students and build a healthy teacher-taught (गुरु-शिष्य) relationship.

Administration: Its basic duty is to maintain peace, harmony and social welfare by creating an environment where each resource persons, organization and institutions has a fair opportunity to collectively complement without discrimination. It can explore, identify and promote such initiative

Corporate: CSR is a statutory provision for corporate to invest on social welfare, and in turn avail tax exemptions. Education is a sector, which

must find a place in CSR programme, and may do it by deputing their qualified personal to schools. In the culture of open office hours, IOMS is an excellent opportunity creating a win-win situation, where their qualified employees mentor from work place at pre-designated hours, without loss of work. This is more akin to corporate which are not involved in line-production.

ICT Vendors: Domain of business is extensive to the extent one can harness opportunities. This initiative to address educational needs at bottom of the pyramid has huge potential of economics of scale. All that is expected of them is to connect with such initiatives, identify ground level needs, technological solutions which are economical yet robust, and create visibility of the solution that they can offer by creating few learning centres operational.

Government: There are many programs launched by every government with good intentions. But, by the time it reaches to ground level it loses its steam. There is a similar programme VIDYANJALI which invites participation from people across country to strengthen education system. Despite, offering the initiative more than a year ago, by GyanVigyanSarita, it is still awaiting reciprocation. Implementation mechanism of government needs to be reinforced.

Every Other Person: Main root cause of all socio-economic problems in present time is not un-education but ill-education. Reforming educational thrust to groom competence to compete among unprivileged children is democratization of education in spiritual sense. This will entail peace, harmony, growth with co-existence. This is the best legacy which one may like to leave behind for his most beloved descendents. All that it requires is a pro-action without waiting for others to follow.

Summary: Advise of President of India on the eve of 69th Republic Day, to reform education to become thought provoking, and a real step is needed to initiate a process which is indiscriminate in manner and is without fear or favour.

शिक्षा प्रणाली के नवोन्मुख आयाम

निरंजन धुलेकर

लार्ड मैकाले ने गुलाम भारत में 'बाबू उत्पादन फैक्ट्री' हेतु जो शिक्षा प्रणाली स्थापित की, उसका असर स्वतंत्र भारत में काफी दिनों तक रहा।

नव भारत के निर्माताओं को यह समझने में थोड़ी देर जरूर लगी कि आने वाले भारत को, यदि मजबूत होना है तो 'चाक एंड टॉक', वाला पुराना देसी फ़लसफ़ा हमारे स्कूलों से हटाना होगा।

संगणक और गणक अब हर बच्चे की उंगलियों पर थिरकते हैं, इसलिए वो रट्टा और घोटम घोट वाला फार्मूला क्लास में चलेगा नहीं।

क्लास में अब हमें बनाने हैं, निर्णय लेने वाले कार्यपालक, प्रबंधक, और विचारक, जिनको आगे देश की कमान संभालनी है।

2005 में नेशनल क्यूरिकुलम फ्रेमवर्क के तहत ये नीतिगत निर्णय लिया गया कि अब तक बच्चे जो पढ़ते और शिक्षक पढ़ाते थे, उसका मूल उद्देश्य परीक्षा पास करना होता था। स्कूल, बच्चे और अभिभावक सिर्फ एक बात पर ही ध्यान देते थे कि परीक्षा में कितने अंक और कौन सी श्रेणी प्राप्त होगी, अब हमें इस सोच को खत्म करना होगा।

अंक और श्रेणी अच्छी आना, और बच्चे का विषय वस्तु को आत्मसात करना, दोनों अलग अलग बातें हैं। विशेष तौर पर, गणित और विज्ञान की कक्षाओं में ब्लैक बोर्ड अब समझाने का पुराना तरीका माना जाता है।

उसकी जगह फिल्में, एनीमेशन और वर्किंग मॉडल्स का उपयोग होने से बच्चे विषय के केंद्र बिंदु यानि कॉन्सेप्ट को बहुत गहराई तक समझने में सक्षम हो रहे हैं। खासकर ऐसे विषयों में जो नग्न आंखों से देखे नहीं जा सकते हैं, जैसे कोशिका संरचना, डीएनए संरचना और कार्य, परागण, कोशिका

विभाजन, चुम्बकत्व, ज्वालामुखी, खगोल संबंधी ज्ञान, सौर मंडल, तारों, सूर्य चंद्र की गति, ग्रहण आदि को कंप्यूटर एनीमेशन और फिल्म के ज़रिए बेहद प्रभावशाली और कम समय में बच्चों को समझाया जा रहा है।

जिस पाठ की विषय वस्तु बच्चा, नग्न आंखों से देख नहीं सकता, उस विषय का उत्तर लिखते समय वह अपनी कल्पनाशीलता पर ही निर्भर रहता है। यह कल्पनाशीलता यथार्थ से काफी दूर और कभी कभी गलत भी होती है, अर्थात् जो ज्ञान पर्दे के पीछे होने के कारण छिपा होता है उसे वह जान नहीं पाता है और वह अपनी परिकल्पना के आधार पर उत्तर लिखता है, जो वास्तव में वांछित नहीं होता है।

बच्चे को सिर्फ ज्ञान ही नहीं देना है, बल्कि उसकी सोचने, समझने, अगले और ऊपर के स्तर को भी आत्मसात करने की क्षमता को बढ़ाने का ठोस प्रयास भी किया जाना है।

अब सिर्फ परीक्षा में पास करवाने के उद्देश्य से शिक्षा देना पर्याप्त नहीं रह गया है, बल्कि बच्चे को दूर तक भविष्य में झांकने की नज़र और स्वयं निर्णय लेने वाली बुद्धि देना भी जरूरी है।

अतः विद्यालय, बच्चे, और अभिभावक, जो शिक्षा प्रणाली के तीन प्रमुख अंग हैं, को एक साथ, एक दिशा में, चलना, सोचना और बोलना होगा ताकि विषय वस्तु को आगे आने वाली कक्षाओं में समझने में कोई दिक्कत न हो।

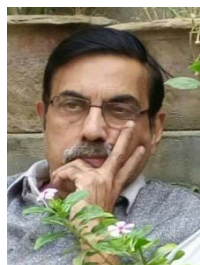
लगभग हर स्कूल में कंप्यूटर्स और स्क्रीन प्रोजेक्टर्स का भरपूर उपयोग शिक्षण में हो रहा है। गणित और विज्ञान जिसमें भौतिकी, जीव विज्ञान, वनस्पति विज्ञान, तीनों सम्मिलित हैं, की प्रयोगशालाओं में थ्री डायमेंशन फिल्मों और एनिमेशन की सहायता से, क्लिष्ट विषयों को आसानी से समझाया जा रहा है।

इसी के साथ ई-पुस्तक, ई-लाइब्रेरी आदि का प्रवेश भी नई शिक्षा के माहौल में हो रही है, जिससे विद्या प्राप्ति के लिए विद्यालय में भारी भरकम किताबों को लाने - ले जाने की आवश्यकता नहीं रह जाएगी। हर घर तक शिक्षा पहुँचाने के नए आयाम विकसित हो रहे हैं।

हो सकता है, आने वाले समय में विद्यालयों का महत्व दिन - ब- दिन कम होने लगे और रिमोट डिजिटल लर्निंग मेकेनिज़्म के

माध्यम से, शिक्षक और शिष्य अपने अपने घरों से ही स्कूलों में होने वाले कार्य को सफलता पूर्वक कर सकें।

अब प्रश्न उठता है कि क्या हम स्कूल रहित शिक्षा प्रणाली की तरफ बढ़ रहे हैं? इस प्रश्न का उत्तर तो भविष्य के गर्भ में छिपा हो सकता है, परंतु एक बात तो अटल है कि शिक्षा प्रणाली कैसी भी हो, 'गुरु बिन ज्ञान न आये गोपाला' !!



The author is retired banker, and graduate in G.B. Pant University of Agriculture and Technology, Pantnagar, and Master Degree in Sociology. He has experience of working numerous NGOs connected with micro-financing. He was associated programs on agriculture credit and priority sector financing. Doordahrdan and Akashwani, Lucknow. He is a social thinker and writer. His poems, short stories and articles find space in various newspapers and magazines. **He is Fourth (new) pillar of the Gyan Vigyan Sarita – a Sociologist.**

e-Mail ID: pekushekhu@gmail.com

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GROWING WITH CONCEPTS

Concepts of an expert are not like a static foundation of a huge structure; rather it is like blood flowing in a vibrant mind.

*During growing into an expert, each one must have used best of the books available on subject and received guidance of best of the teachers. Authors might have had limitations to take every concept thread bare from first principle and so also must be the constraint of teacher while mentoring a class with a diversity of inquisitiveness and focus. As a result, there are instances when on a certain concept a discomfort remains. The only remedy is to live with the conceptual problem and continue to visualize it thread bare till it goes to bottom of heart and that is an **ingenious illustration**.*

In this column an effort is being made to take one topic on Mathematics, Physics and Chemistry in each e-Bulletin and provide its illustration from First Principle. We invite all experts in these subjects to please mail us their ingenious illustrations and it would be our pleasure to include it in the column.

We hope this repository of ingenious illustrations, built over a period of time, would be helpful to ignite minds of children, particularly to aspiring unprivileged students, that we target in this initiative, and in general to all, as a free educational web resource.

This e-Bulletin covers – a) [Mathematics](#), b) [Physics](#), and c) [Chemistry](#). This is just a beginning in this direction. These articles are not replacement of text books and reference books. These books provide a large number of solved examples, problems and objective questions, necessary to make the concepts intuitive, a journey of educational enlightenment.

Looking forward, these articles are being integrated into Mentors' Manual. After completion of series of such articles on Physics it is contemplated to come up representative problems from contemporary text books and Question papers from various competitive examinations and a guide to their solutions in a structured manner, as a dynamic exercise to catalyse the conceptual thought process.

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दस्तक

मृणालिनी घुले

कोयल ने सन्देश सुनाया है गा-गा कर,
मौसम ने हर पत्ते पर लिखे हस्ताक्षर,
स्वागत हो उल्लास भरा हर नव आगत का,
जाती ऋतु को बिदा करो, थोड़ा मुस्काकर ।

संकल्पों के नये क्षितिज तक भरो उड़ानें,
वातायन तो बहुत खुले हैं दीवारों पर,
अन्वेषण की जिज्ञासा ही ज्ञान पिपासा,
कार्य सदा ही रहे जगत के लिए शुभंकर ।

छूट न जाए कोई भी क्षण हाथ से देखो,
अवसर आता नहीं द्वार पर, दस्तक देकर ॥

क्या रस्ते क्या मंजिलें
चल पड़े हैं काफिले
वह बुलंदी चूम लो
हो फलक कदमों तले ।

फिक्र क्या कोई अगर
संग चले या न चले
चल पड़ेंगे सिलसिले
चलने से ही होंगे कम
मंजिलों के फासले ॥



कवियत्री एक सामाजिक चिंतक एवं विचारक हैं । आपकी कविताएँ वर्तमान पर्यवेक्ष्य में बुद्धि-जीवियों को उनके सामाजिक उत्तरदायित्व के प्रति उन्हें चिंतन के लिए प्रेरित करती हैं । आपकी लेखनी प्रादेशिक एवं राष्ट्रीय स्तर पर प्रकाशित है।

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शिक्षकों से अनुरोध (अब्राहम लिंकन के पत्र पर आधारित)

के. हेमलता

हे गुरु श्रेष्ठ !

मैं जानती हूँ और मानती हूँ,

कि हर व्यक्ति न तो सदा सही होता है, न सच्चा,

किन्तु तुम्हें उसे सिखाना होगा कि वह पहचाने बुरा;

बुरे व्यक्तियों के साथ=साथ आदर्श बनाने वाले भी होते हैं

स्वार्थी राजनेताओं के साथ-साथ मित्र भी होते हैं,

हर कुरूपता के साथ सुन्दर चित्र भी होते हैं;

चाहे कितना ही समय लग जाये, पर उसे सिखाना

उपहार पाने से अधिक मूल्यवान है स्वयं कमाकर खाना,

अपनी हार को वह कैसे झेले, यह सिखाना

और साथ ही साथ जीत की खुशियों मनाना;

उसे दिखा सको तो दिखाना--

किताबों में छिपा खजाना,

और उसे समय देना सोचने के लिए-

जैसे आकाश में ऊँचे उड़ते पक्षियों की खुशी,

सूरज की रोशनी में मधुमक्खियों का गीत,

हरे-भरे पहाड़ों पर फूलों की बातचीत;

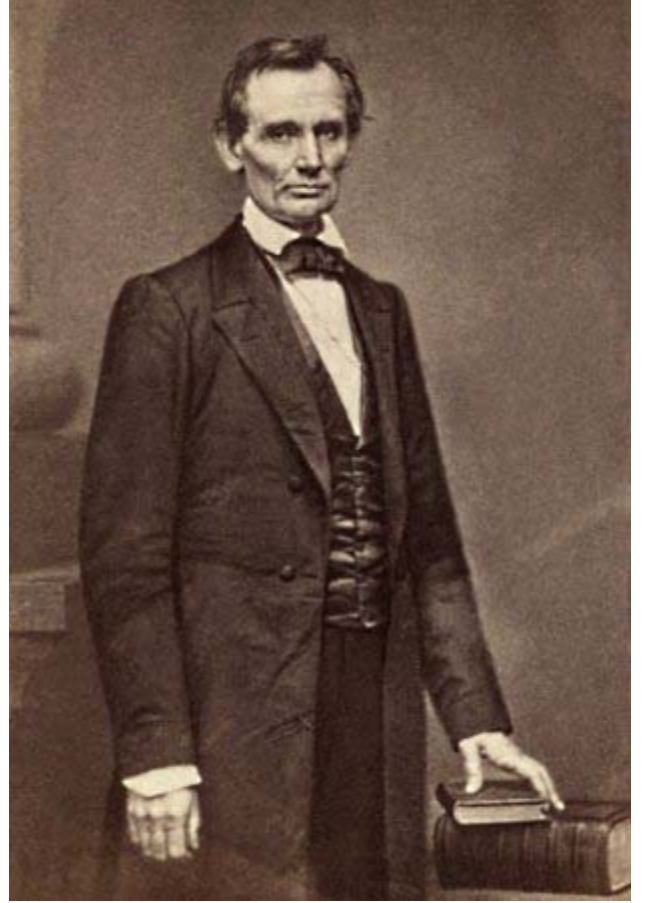
उसे यह बतलाना--

कि दुनिया के शोर में वह अपने मन की सुनसके,

हर बात को सत्य की कसौटी पर कसकर देख सके,

यदि सिखा सको तो सिखाना, दुःख में भी मुस्कराना,

कष्ट में रहकर भी गीत खुशी के गाना ।।



लेखिका रामकृष्ण मिशन हाईस्कूल, विशाखापट्टनम, में पिछले निरंतर १४ वर्षों से हिंदी- प्राध्यापिका के पद पर कार्यरत हैं ।

E-mail ID: hemplatakollata@gmail.com

Students' Section

चिड़िया के बच्चे

एन. कीर्तिप्रिया

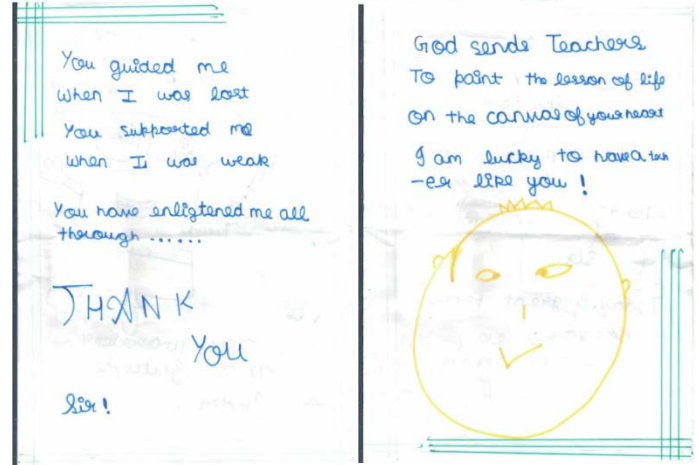
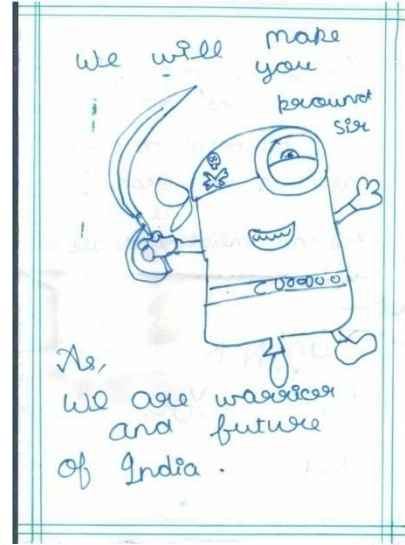
चिड़िया के दो बच्चे भोले,
चीची करके माँ से बोले,
माँ, क्या हम भी पर फैलाये,
झटफट उड़कर नीचे आये ?

चिड़िया बोली- भोले बच्चे,
अभी तुम्हारे पर है कच्चे।
तुम इनको मजबूत बनालो,
फिर उड़ दुनिया देखो-भालो।।

कुछ दिन ऐसे बीत गए जब,
पंछी उड़ना सीख गए तब।
उड़ते लगते कैसे प्यारे,
माँ के पीछे पंख पसारें।।



कवियत्री कक्षा ९ वीं, रामकृष्ण मिशन
हाईस्कूल, विशाखापट्टनम, की छात्रा हैं।
वे, शाला में नवगठित IOMS अध्ययन
केंद्र की नियमित छात्रा हैं।



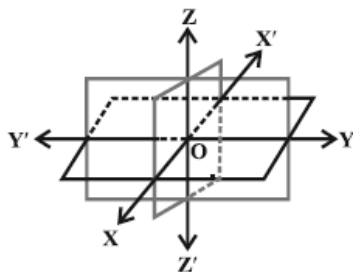
Extempore creation by Shubham, Student Class VIIIth, a regular student of IOMS Learning Centre, at Warjurkar Classes, Pune

THREE-DIMENSIONAL COORDINATE GEOMETRY

Prof. SB DHAR

In three dimensions, the coordinate axes of a rectangular Cartesian coordinate system are three mutually perpendicular lines. They are called x-axis, y-axis, and z-axis. The three planes taking two axes together are the coordinate planes XOY, YOZ and ZOX where O is the point of intersection of the three axes, ie the Origin. The coordinates of a point in three dimensional geometry is written as (x,y,z) where x,y,z are the distances of the point from the YOZ, XOZ, XOY-planes.

In 2-dimensional geometry, the plane is divided in the 4 parts that are called quadrants; but in the 3-dimensional geometry, the space is divided into 8 parts and they are called octants.



These octants are:

XOYZ (I) (+,+,+), X'OYZ(II) (-,+,+),

X'OY'Z(III) (-,-,+), XOY'Z(IV) (+,-,+),

XOYZ'(V) (+,+,-), X'OYZ'(VI) (-,+,-),

X'OY'Z'(VII) (-,-,-), XOY'Z'(VIII) (+,-,-)

Some Important Facts

1. Coordinates of Origin (0,0,0)
2. Equation of x-axis $y=0, z=0$
3. Equation of y-axis $x=0, z=0$
4. Equation of z-axis $x=0, y=0$
5. Equation of XOY plane $z=0$
6. Equation of YOZ plane $x=0$

7. Equation of XOZ plane $y=0$

8. Distance between two points $A(x_1, y_1, z_1)$ and

$$B(x_2, y_2, z_2): \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

9. Distance of a Point $P(x, y, z)$ from the Coordinate axes X, Y and Z are given respectively by

$$\sqrt{y^2 + z^2}, \sqrt{x^2 + z^2}, \sqrt{x^2 + y^2}$$

10. Section formula: If $A(x_1, y_1, z_1)$ and $B(x_2, y_2, z_2)$ are the points, and point P divides the line joining AB into the ratio $m:n$ then the coordinates of P is given by

$$\left(\frac{nx_1 + mx_2}{m+n}, \frac{ny_1 + my_2}{m+n}, \frac{nz_1 + mz_2}{m+n} \right). \text{ This is also}$$

called formulae for internal division. For external division one of m and n becomes –negative as below:

$$\left(\frac{nx_1 - mx_2}{n-m}, \frac{ny_1 - my_2}{n-m}, \frac{nz_1 - mz_2}{n-m} \right)$$

11. Mid point of AB

$$= \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}, \frac{z_1 + z_2}{2} \right)$$

12. Centroid of the triangle

$$\left(\frac{x_1 + x_2 + x_3}{3}, \frac{y_1 + y_2 + y_3}{3}, \frac{z_1 + z_2 + z_3}{3} \right)$$

13. Centroid of the tetrahedron

$$\left(\frac{x_1 + x_2 + x_3 + x_4}{4}, \frac{y_1 + y_2 + y_3 + y_4}{4}, \frac{z_1 + z_2 + z_3 + z_4}{4} \right)$$

14. The X-Y plane divides the line segment joining (x_1, y_1, z_1) and (x_2, y_2, z_2) in the ratio $-z_1/z_2$. The Y-Z plane divides in the ratio $-x_1/x_2$ and the Z-X plane divides in $-y_1/y_2$ ratio.

15. l, m, n are direction cosines if $l^2 + m^2 + n^2 = 1$ otherwise they are called direction ratios, i.e.

$$\cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma = 1 \text{ and}$$

$$\sin^2 \alpha + \sin^2 \beta + \sin^2 \gamma = 2.$$

16. If a, b, c are direction ratios or direction numbers i.e. $a^2 + b^2 + c^2 \neq 1$ then the direction ratios are given by

$$l = \pm \frac{a}{\sqrt{a^2 + b^2 + c^2}},$$

$$m = \pm \frac{b}{\sqrt{a^2 + b^2 + c^2}}, n = \pm \frac{c}{\sqrt{a^2 + b^2 + c^2}}$$

17. If $\vec{OP} = x\hat{i} + y\hat{j} + z\hat{k}$ then $|\vec{OP}| = \sqrt{x^2 + y^2 + z^2}$ is called modulus of vector OP and is represented by r .

18. Area of the triangle ABC whose vertices are $A(x_1, y_1, z_1)$, $B(x_2, y_2, z_2)$ and $C(x_3, y_3, z_3)$ is given by

$$\Delta = \sqrt{\Delta_x^2 + \Delta_y^2 + \Delta_z^2} \text{ where}$$

$$\Delta_x = \frac{1}{2} \begin{vmatrix} y_1 & y_2 & y_3 \\ z_1 & z_2 & z_3 \\ 1 & 1 & 1 \end{vmatrix}, \quad \Delta_y = \frac{1}{2} \begin{vmatrix} x_1 & x_2 & x_3 \\ z_1 & z_2 & z_3 \\ 1 & 1 & 1 \end{vmatrix}$$

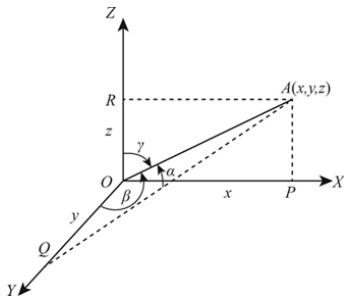
$$\Delta_z = \frac{1}{2} \begin{vmatrix} x_1 & x_2 & x_3 \\ y_1 & y_2 & y_3 \\ 1 & 1 & 1 \end{vmatrix}.$$

19. Condition for three points $A(x_1, y_1, z_1)$, $B(x_2, y_2, z_2)$ and $C(x_3, y_3, z_3)$ to be collinear or to be in a line, is given

$$\text{by } \frac{x_1 - x_2}{x_2 - x_3} = \frac{y_1 - y_2}{y_2 - y_3} = \frac{z_1 - z_2}{z_2 - z_3}.$$

20. **Direction cosines** are the cosines of the angles made with the axes and is given by

$$l = \cos \alpha = \frac{x}{r}, m = \cos \beta = \frac{y}{r}, n = \cos \gamma = \frac{z}{r}$$



Where r is the distance of the point from the Origin ie

$$OA = \sqrt{x^2 + y^2 + z^2}$$

21. Direction cosines of x-axis is $\langle 1, 0, 0 \rangle$.
 22. Direction cosines of y-axis is $\langle 0, 1, 0 \rangle$.
 23. Direction cosines of z-axis is $\langle 0, 0, 1 \rangle$.
 24. Direction cosines of a line are unique but direction ratios are not unique and can be infinite.
 25. Angle between two lines with direction cosines $\langle l_1, m_1, n_1 \rangle$ and $\langle l_2, m_2, n_2 \rangle$ is given by $\cos \theta = l_1 l_2 + m_1 m_2 + n_1 n_2$

26. Angle between two lines with direction ratios $\langle a_1, b_1, c_1 \rangle$ and $\langle a_2, b_2, c_2 \rangle$ is given by $\cos \theta$

$$= \frac{a_1 a_2 + b_1 b_2 + c_1 c_2}{\sqrt{a_1^2 + b_1^2 + c_1^2} \sqrt{a_2^2 + b_2^2 + c_2^2}}$$

27. Lines with direction cosines $\langle l_1, m_1, n_1 \rangle$ and $\langle l_2, m_2, n_2 \rangle$ are parallel if $l_1 = l_2$; $m_1 = m_2$; $n_1 = n_2$
 28. Lines with direction ratios $\langle a_1, b_1, c_1 \rangle$ and $\langle a_2, b_2, c_2 \rangle$ are parallel if $a_1 / a_2 = b_1 / b_2 = c_1 / c_2$
 29. Lines with direction cosines $\langle l_1, m_1, n_1 \rangle$ and $\langle l_2, m_2, n_2 \rangle$ are perpendicular if $l_1 l_2 + m_1 m_2 + n_1 n_2 = 0$
 30. Lines with direction ratios $\langle a_1, b_1, c_1 \rangle$ and $\langle a_2, b_2, c_2 \rangle$ are perpendicular if $a_1 a_2 + b_1 b_2 + c_1 c_2 = 0$
 31. Length of projection of PQ on AB if $P(x_1, y_1, z_1)$, $Q(x_2, y_2, z_2)$ and direction cosines of AB are l, m, n is given by $(x_2 - x_1)l + (y_2 - y_1)m + (z_2 - z_1)n$.
 32. The direction cosines of a line joining $P(x_1, y_1, z_1)$ and $Q(x_2, y_2, z_2)$ are

$$\frac{x_2 - x_1}{PQ}, \frac{y_2 - y_1}{PQ}, \frac{z_2 - z_1}{PQ}$$

where

$$PQ = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

Straight Lines

- Equation of a straight line with direction cosines $\langle l, m, n \rangle$ and passing through point (x_1, y_1, z_1) is given

$$\text{by } \frac{x-x_1}{l} = \frac{y-y_1}{m} = \frac{z-z_1}{n}$$

- Equation of a straight line with direction ratios $\langle a, b, c \rangle$ and passing through point (x_1, y_1, z_1) is given by

$$\frac{x-x_1}{a} = \frac{y-y_1}{b} = \frac{z-z_1}{c}$$

- Coordinates of any point on the line

$$\frac{x-x_1}{l} = \frac{y-y_1}{m} = \frac{z-z_1}{n} = k \text{ (say) is given by } (x_1+kl, y_1+km, z_1+kn).$$

- Equation of x axis is given by $\frac{x-0}{1} = \frac{y-0}{0} = \frac{z-0}{0}$

as it passes through $(0,0,0)$ and the direction cosines of x-axis are $\langle 1, 0, 0 \rangle$ or it can be written as $y=0$ and $z=0$.

- Equation of y-axis is given by $\frac{x-0}{0} = \frac{y-0}{1} = \frac{z-0}{0}$

as it passes through $(0,0,0)$ and the direction cosines of y axis are $\langle 0, 1, 0 \rangle$ or it can be written as $x=0$ and $z=0$.

- Equation of z-axis is given by $\frac{x-0}{0} = \frac{y-0}{0} = \frac{z-0}{1}$

as it passes through $(0,0,0)$ and the direction cosines of z axis are $\langle 0, 0, 1 \rangle$ or it can be written as $x=0$ and $y=0$.

- Equation of a line passing through two points $P(x_1, y_1, z_1)$, $Q(x_2, y_2, z_2)$ is given by

$$\frac{x-x_1}{x_2-x_1} = \frac{y-y_1}{y_2-y_1} = \frac{z-z_1}{z_2-z_1}$$

8. Intersection of two lines:

- If the lines are on the same plane and not parallel, then they will cut in a point.
- If the lines are on the same plane and are parallel then they will not intersect each other.
- If the lines are on the different planes then they may neither be parallel nor intersect each other. These lines are called *skew lines*.

of two lines:

Assume the lines be $\frac{x-x_1}{a_1} = \frac{y-y_1}{b_1} = \frac{z-z_1}{c_1} = t$ (say) and

$$\frac{x-x_2}{a_2} = \frac{y-y_2}{b_2} = \frac{z-z_2}{c_2} = s \text{ (say)}$$

- Write the general points on the two line as $(a_1t+x_1, b_1t+y_1, c_1t+z_1)$ and $(a_2s+x_2, b_2s+y_2, c_2s+z_2)$
- Equate the two coordinates: $a_1t+x_1 = a_2s+x_2$, $b_1t+y_1 = b_2s+y_2$, $c_1t+z_1 = c_2s+z_2$
- Solve any two equations for t and s .
- Put the value of t and s in the third equation.
- If it satisfies the third equation, the lines will intersect otherwise they will not intersect.
- Put the value of t or s to find the coordinates of the point of intersection in general point.

Perpendicular distance of a point $P(x_1, y_1, z_1)$ from a line:

Assume the line to be $\frac{x-a}{l} = \frac{y-b}{m} = \frac{z-c}{n} = k$ (say),

- Write the general point on the line as $M(lk+a, mk+b, nk+c)$
- The perpendicular distance from P to M is given by $\sqrt{(lk+a-x_1)^2 + (mk+b-y_1)^2 + (nk+c-z_1)^2}$ if PM is perpendicular to the given line i.e. $(lk+a-x_1)l + (mk+b-y_1)m + (nk+c-z_1)n = 0$.
- The equation of the perpendicular line can be written using the two-points form i.e.

$$\frac{x-a}{lk+a-x_1} = \frac{y-b}{mk+b-y_1} = \frac{z-c}{nk+c-z_1}$$

- Shortest distance between two lines (in Cartesian

$$\text{form) } \frac{x-x_1}{l_1} = \frac{y-y_1}{m_1} = \frac{z-z_1}{n_1},$$

Working Rule to find the point of intersection

$$\frac{x-x_2}{l_2} = \frac{y-y_2}{m_2} = \frac{z-z_2}{n_2} \text{ is given by}$$

$$d = \frac{\begin{vmatrix} x_2-x_1 & y_2-y_1 & z_2-z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix}}{\sqrt{(m_1n_2-m_2n_1)^2 + (n_1l_2-l_1n_2)^2 + (l_1m_2-m_1l_2)^2}}.$$

5. Shortest distance between two skew lines is such a line that is perpendicular to both the skew lines.

6. Condition for two lines to intersect

$$\frac{x-x_1}{l_1} = \frac{y-y_1}{m_1} = \frac{z-z_1}{n_1}, \quad \frac{x-x_2}{l_2} = \frac{y-y_2}{m_2} = \frac{z-z_2}{n_2}$$

is given by

$$d = \frac{\begin{vmatrix} x_2-x_1 & y_2-y_1 & z_2-z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix}}{\sqrt{(m_1n_2-m_2n_1)^2 + (n_1l_2-l_1n_2)^2 + (l_1m_2-m_1l_2)^2}} = 0 \text{ i.e.}$$

$$\begin{vmatrix} x_2-x_1 & y_2-y_1 & z_2-z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0.$$

7. The number of lines that are equally inclined to the axes are 4.
8. The direction cosines of the line equally inclined to the coordinate axes are $\langle \pm 1/\sqrt{3}, \pm 1/\sqrt{3}, \pm 1/\sqrt{3} \rangle$
9. The maximum value of $lmn = 1/(3\sqrt{3})$ where l, m, n are the direction cosines.
10. Skew lines are lines in space which are neither parallel nor intersecting. They lie in different planes i.e. skew lines are non-coplanar lines or parallel lines are not skew lines.
11. Angle between skew lines is the angle between two intersecting lines drawn from any point (preferably through origin) parallel to each of the skew lines.
12. Intersection of two planes forms a straight line.
13. Joint equation of a line is represented by two planes: $a_1x+b_1y+c_1z+d_1=0$ and $a_2x+b_2y+c_2z+d_2=0$.
14. Point of intersection of a line and a plane is a point.

If the line is $\frac{x-x_1}{l} = \frac{y-y_1}{m} = \frac{z-z_1}{n} = r$ and the plane is $ax+by+cz+d=0$ then the point on the line will

be given by $(rl+x_1, mr+y_1, nr+z_1)$. This point will lie on the plane. So put the value of x, y, z and get the value of r . and hence the point of intersection.

15. Condition to lie a line in a plane; if the line is

$$\frac{x-x_1}{l} = \frac{y-y_1}{m} = \frac{z-z_1}{n} \text{ and the plane is } ax+by+cz+d=0 \text{ then } al+bm+cn=0 \text{ and } ax_1+by_1+cz_1+d=0$$

Fundamental Theorem in Space

If a, b, c are non-zero, non-coplanar vectors in space, then there exists unique $x, y, z \in \mathbb{R}$ such that $r = x a + y b + z c$.

Definition of a plane

A surface is called a plane if every point of the line joining any two random points on it also lies on it.

Equation of a plane

1. Equation of XOY-plane is given by $z=0$.
2. Equation of YOZ plane is given by $x=0$.
3. Equation of XOZ plane is given by $y=0$.
4. Equation of any plane parallel to XOY plane is given by $z=c$, the positive or negative sign of c will determine the exact state of plane as c is the distance from the z -axis.
5. Equation of any plane parallel to YOZ plane is given by $x=c$, the positive or negative sign of c will determine the exact state of plane as c is the distance from the x -axis.
6. Equation of any plane parallel to XOZ plane is given by $y=c$, the positive or negative sign of c will determine the exact state of plane as c is the distance from the y -axis.
7. Equation of a plane is calculated under three conditions.
8. Equation of a plane is of the form $ax+by+cz+d=0$ where a, b, c are the direction ratios of the normal to the given plane.
9. Equation of a plane passing through Origin $(0,0,0)$ is given by $ax+by+cz=0$.
10. Equation of a plane perpendicular to XOY plane or parallel to z -axis is $ax+by+d=0$.

11. Equation of a plane perpendicular to YOZ plane or parallel to x-axis is $by+cz+d=0$.
12. Equation of a plane perpendicular to XOZ plane or parallel to y-axis is $ax+cz+d=0$.
13. Equation of a plane passing through the intersection of two planes $ax+by+cz+d=0$ and $a'x+b'y+c'z+d'=0$ is given by $(ax+by+cz+d)+\lambda(a'x+b'y+c'z+d')=0$ where λ is a parameter whose value can be evaluated under given condition.
14. Equation of plane $ax+by+cz+d=0$ represents a system of planes perpendicular to the line $x/a=y/b=z/c$.
15. Normal form of the vector equation of the plane is given by $\mathbf{r} \cdot \mathbf{n} = p$ where \mathbf{n} is the unit vector normal to the plane and p is the perpendicular distance from the origin to the plane.
16. Equation of a plane passing through one point (x_1, y_1, z_1) is given by $a(x-x_1)+b(y-y_1)+c(z-z_1)=0$, where a, b, c are the direction ratios of the normal to the plane.
17. Equation of a plane passing through three points (x_1, y_1, z_1) , (x_2, y_2, z_2) , (x_3, y_3, z_3) is given by

$$\begin{vmatrix} x & y & z & 1 \\ x_1 & y_1 & z_1 & 1 \\ x_2 & y_2 & z_2 & 1 \\ x_3 & y_3 & z_3 & 1 \end{vmatrix} = 0$$

18. Angle between two planes in case of Cartesian equations: $a_1x+b_1y+c_1z+d_1=0$ and $a_2x+b_2y+c_2z+d_2=0$ is defined as the angle between their normals and is given by

$$\cos \theta = \frac{a_1a_2 + b_1b_2 + c_1c_2}{\sqrt{a_1^2 + b_1^2 + c_1^2} \sqrt{a_2^2 + b_2^2 + c_2^2}}.$$

19. If planes are perpendicular to each other then $a_1a_2 + b_1b_2 + c_1c_2 = 0$
20. If planes are parallel to each other then $a_1/a_2 = b_1/b_2 = c_1/c_2$
21. Intercept form of a plane is given by $x/a + y/b + z/c = 1$
22. Any plane parallel to a given plane $ax+by+cz+d=0$ is given by $ax+by+cz+\lambda=0$ where λ is calculated under some given conditions i.e. only constant term is changed.

23. Perpendicular distance of a point (x_1, y_1, z_1) from a plane $ax+by+cz+d=0$ is given by $\frac{|ax_1+by_1+cz_1+d|}{\sqrt{a^2+b^2+c^2}}$
24. Distance between two parallel planes: $ax+by+cz+d_1=0$ and $ax+by+cz+d_2=0$ is given by $\frac{|d_1-d_2|}{\sqrt{a^2+b^2+c^2}}$.
25. If a plane meets coordinate axes A, B, C in such a way that the centroid is (p, q, r) then the equation of the plane will be $x/p + y/q + z/r = 3$.
26. The equation of the plane $lx+my+nz=p$ represents a plane whose distance from the origin is p and the direction cosines of the normal to the plane are $\langle l, m, n \rangle$.
27. Equations of planes bisecting angles between two planes

If the planes are $a_1x+b_1y+c_1z+d_1=0$ and $a_2x+b_2y+c_2z+d_2=0$:

$$\frac{a_1x+b_1y+c_1z+d_1}{\sqrt{a_1^2+b_1^2+c_1^2}} = \pm \frac{a_2x+b_2y+c_2z+d_2}{\sqrt{a_2^2+b_2^2+c_2^2}}.$$

28. Angle bisector is an acute angle bisector if the angle between the bisector plane and one of the plane is less than 45° , otherwise it is an obtuse angle bisector.
29. Origin lies in the acute angle between the planes if $a_1a_2+b_1b_2+c_1c_2$ is (+)positive and it lies in the obtuse angle if it is (-)negative if both d_1 and d_2 are positive or of same sign.

Plane and Line

1. Equation of a plane through a line (if the equation of the line is in general form $a_1x+b_1y+c_1z+d_1=0$, $a_2x+b_2y+c_2z+d_2=0$): $(a_1x+b_1y+c_1z+d_1)+\lambda(a_2x+b_2y+c_2z+d_2)=0$ where λ is a parameter whose value may be found under given condition.
2. Equation of a plane through a line (if the line is in symmetrical form $\frac{x-x_1}{l} = \frac{y-y_1}{m} = \frac{z-z_1}{n}$): $a(x-$

$x_1)+b(y-y_1)+c(z-z_1)=0$ where a, b, c are given by $al+bm+cn=0$

3. Equation of a plane (with direction ratios of the normal to the plane $\langle a, b, c \rangle$) through a line (with direction cosines $\langle l_1, m_1, n_1 \rangle$) and parallel to another line (with direction cosines $\langle l_2, m_2, n_2 \rangle$): $al_2+bm_2+cn_2=0$ as the normal will be perpendicular to

the parallel line and
$$\begin{vmatrix} x-x_1 & y-y_1 & z-z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0$$
.

4. Condition for a line $\frac{x-x_1}{l} = \frac{y-y_1}{m} = \frac{z-z_1}{n}$ to lie in a plane $ax+by+cz+d=0$ (the equations in Cartesian form): $ax_1+by_1+cz_1+d=0$, $al+bm+cn=0$.

5. Angle between a line and a plane is defined as “the complement of the angle between the line and the normal to the plane”.

6. In Cartesian form if the line is $\frac{x-x_1}{l} = \frac{y-y_1}{m} = \frac{z-z_1}{n}$ and the plane is $ax+by+cz+d=0$ and θ is the angle between the line and the plane then it is given by

$$\sin \theta = \frac{al+bm+cn}{\sqrt{a^2+b^2+c^2}\sqrt{l^2+m^2+n^2}}.$$

7. If the line is parallel to the plane then $al+bm+cn=0$.
8. If the line is perpendicular to the plane then $a/l=b/m=c/n$.

9. If the lines $\frac{x-x_1}{l_1} = \frac{y-y_1}{m_1} = \frac{z-z_1}{n_1}$,

$$\frac{x-x_2}{l_2} = \frac{y-y_2}{m_2} = \frac{z-z_2}{n_2} \text{ are coplanar (i.e.}$$

intersecting) then
$$\begin{vmatrix} x_2-x_1 & y_2-y_1 & z_2-z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0$$
 and

the equation of the plane containing two lines:

$$\begin{vmatrix} x-x_1 & y-y_1 & z-z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0 \quad \text{or}$$

$$10. \begin{vmatrix} x-x_2 & y-y_2 & z-z_2 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0.$$

Some Solved Problems:

1. Find the equation of the set of points P such that $PA^2+PB^2=2k^2$, where A and B are the points (3,4,5) and (-1,3,-7) respectively.

Solution:

Assume the point P(x,y,z).

$$PA^2 + PB^2 = 2k^2 \Rightarrow (x-3)^2 + (y-4)^2 + (z-5)^2 + (x+1)^2 + (y-3)^2 + (z+7)^2 = 2k^2$$

$$\Rightarrow 2x^2 + 2y^2 + 2z^2 - 4x - 14y + 4z + 109 = 2k^2$$

2. Using section formula, prove that the three points A(-4,6,10), B(2,4,6) and C(14,0,-2) are collinear.

Solution:

Assume that Point B divides line segment joining A and C in the ratio k:1.

Then

$$2 = \frac{14k-4}{k+1}, \quad 4 = \frac{0k+6}{k+1}, \quad 6 = \frac{-2k+10}{k+1}$$

We get $k = \frac{1}{2}$ from all the three equations, hence it is

proved that B divides the line segment joining A and C.

3. Find the ratio in which the line segment joining the points A (4,8,10) and B (6,10,-8) is divided by the YZ-plane.

Solution:

On Y-Z plane $x=0$ hence let the coordinates of the point of intersection be (0,y,z)

We shall use the coordinate of x-axis to determine the ratio.

Let the ratio be $k:1$ in which the YZ plane divides line segment AB

$$\text{hence } 0 = \frac{6k+4}{k+1}$$

$\Rightarrow k = -\frac{2}{3}$. It means AB is being divided externally in the ratio 2:3.

4. Find the direction cosines of the line passing through the two points P(-2,4,-5) and Q (1,2,3).

Solution:

We know that the direction cosines of a line joining $P(x_1, y_1, z_1)$ and $Q(x_2, y_2, z_2)$ are given by

$$\frac{x_2 - x_1}{PQ}, \frac{y_2 - y_1}{PQ}, \frac{z_2 - z_1}{PQ}$$

$$\text{Where } PQ = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

$$\text{Hence } PQ = \sqrt{9 + 4 + 64} = \sqrt{77}$$

$$\text{And direction cosines are } \left\langle \frac{3}{\sqrt{77}}, \frac{-2}{\sqrt{77}}, \frac{8}{\sqrt{77}} \right\rangle.$$

5. Find the direction cosines of x, y and z axes.

Solution:

We know that x-axis makes angle of 0° with x-axis, 90° with y-axis, and 90° with z-axis.

Hence, the direction cosines of x-axis are $\cos 0^\circ$, $\cos 90^\circ$, $\cos 90^\circ$ i.e., 1, 0, 0

Similarly, the direction cosines of y-axis are 0, 1, 0 and the direction cosines of z-axis are 0, 0, 1.

6. Show that the points A (2,3,-4), B (1,-2,3) and C (3,8,-11) are collinear.

Solution:

$$\text{drs of AB} = \langle 1-2, -2-3, 3+4 \rangle \Rightarrow \langle -1, -5, 7 \rangle$$

$$\text{drs of BC} = \langle 3-1, 8+2, -11-3 \rangle \Rightarrow \langle 2, 10, -14 \rangle \\ \Rightarrow \langle 1, 5, -7 \rangle$$

$$\text{drs of AC} = \langle 3-2, 8-3, -11+4 \rangle \Rightarrow \langle 1, 5, -7 \rangle$$

Obviously, drs of AB, BC, AC are same, hence A, B, C are collinear.

7. Find the Cartesian equation of the line that passes through the point (5,2,-4) and which is parallel to the line whose direction ratios are 3,2,-8.

Solution:

We know that the equation of a straight line with direction ratios $\langle a, b, c \rangle$ and passing through point

$$(x_1, y_1, z_1) \text{ is given by } \frac{x-x_1}{a} = \frac{y-y_1}{b} = \frac{z-z_1}{c}$$

Hence the required equation of the line is

$$\frac{x-5}{3} = \frac{y-2}{2} = \frac{z+4}{-8}$$

8. Find the Cartesian equation of the line that passes through the points (-1,0,2) and (3,4,6).

Solution:

We know that the Equation of a line that passes through two points (x_1, y_1, z_1) , (x_2, y_2, z_2) is given by

$$\frac{x-x_1}{x_2-x_1} = \frac{y-y_1}{y_2-y_1} = \frac{z-z_1}{z_2-z_1}$$

Hence the required equation of the line is

$$\frac{x+1}{3+1} = \frac{y-0}{4-0} = \frac{z-2}{6-2}$$

$$\text{Or } \frac{x+1}{4} = \frac{y}{4} = \frac{z-2}{4}$$

$$\text{Or } x+1 = y = z-2$$

9. Find the angle between the pair of lines

$$\frac{x+3}{3} = \frac{y-1}{5} = \frac{z+3}{4} \text{ and } \frac{x+1}{1} = \frac{y-4}{1} = \frac{z-5}{2}$$

Solution:

Angle between two lines with direction ratios $\langle a_1, b_1, c_1 \rangle$ and $\langle a_2, b_2, c_2 \rangle$ is given by

$$\cos \theta = \frac{a_1 a_2 + b_1 b_2 + c_1 c_2}{\sqrt{a_1^2 + b_1^2 + c_1^2} \sqrt{a_2^2 + b_2^2 + c_2^2}}$$

Here $\langle a_1, b_1, c_1 \rangle = \langle 3, 5, 4 \rangle$ and $\langle a_2, b_2, c_2 \rangle = \langle 1, 1, 2 \rangle$

$$\text{Hence } \cos \theta = \frac{3+5+8}{\sqrt{9+25+16} \sqrt{1+1+4}}$$

Or

$$\cos \theta = \frac{16}{\sqrt{50} \sqrt{6}} = \frac{16}{10\sqrt{3}} = \frac{8}{5\sqrt{3}} = \frac{8\sqrt{3}}{15}$$

10. Find the distance between the lines given by

$$\frac{x-3}{2} = \frac{y+10}{-9} = \frac{z-1}{-2} \text{ and } \frac{x+5}{4} = \frac{y+3}{-18} = \frac{z-6}{-4}$$

Solution:

This question relates to the distance between two parallel lines.

$$\text{Let } l_1 : \frac{x-3}{2} = \frac{y+10}{-9} = \frac{z-1}{-2} \quad \text{and}$$

$$l_2 : \frac{x+5}{4} = \frac{y+3}{-18} = \frac{z-6}{-4}$$

Obviously both the lines are parallel.

Assume a plane that is orthogonal to the parallel lines i.e. the normal to the plane will be collinear with the direction ratios of the lines.

Let the plane be $Ax+By+Cz+D=0$

$$A=2, B=-9, C=-2$$

Let this plane pass through the point $(-5, -3, 6)$ of the second line.

$$\text{Then } 2(-5) - 9(-3) - 2(6) + D = 0 \text{ or } D = -5$$

$$\text{So the plane is } 2x - 9y - 2z - 5 = 0$$

Now find out the point of intersection of this plane and the first line.

$$\frac{x-3}{2} = \frac{y+10}{-9} = \frac{z-1}{-2} = t$$

Or

$$x = 2t + 3, y = -9t - 10, z = -2t + 1$$

this point lies on the plane.

$$\text{Hence } 2(2t+3) - 9(-9t-10) - 2(-2t+1) - 5 = 0$$

$$\text{Or } t = -1$$

Therefore the point is $(1, -1, 3)$

Now the required distance is the distance between $(-5, -3, 6)$ and $(1, -1, 3)$

$$\text{i.e., } \sqrt{(1+5)^2 + (-1+3)^2 + (3-6)^2} = 7$$

11. Find the value(s) of p so that the lines

$$\frac{1-x}{3} = \frac{7y-14}{2p} = \frac{z-3}{2} \text{ and}$$

$$\frac{7-7x}{3p} = \frac{y-5}{1} = \frac{6-z}{5} \text{ are at right angles.}$$

Solution:

Let us rewrite the equations in standard form

$$\frac{x-1}{-3} = \frac{y-2}{2p/7} = \frac{z-3}{2} \text{ and}$$

$$\frac{x-1}{-3p/7} = \frac{y-5}{1} = \frac{z-6}{-5}$$

Use the concept:

Lines with direction ratios $\langle a_1, b_1, c_1 \rangle$ and $\langle a_2, b_2, c_2 \rangle$ are perpendicular if $a_1a_2 + b_1b_2 + c_1c_2 = 0$

Hence,

$$(-3)\left(-\frac{3p}{7}\right) + \left(\frac{2p}{7}\right)(1) + (2)(-5) = 0$$

$$\frac{9p}{7} + \frac{2p}{7} - 10 = 0 \Rightarrow \frac{11p}{7} = 10 \Rightarrow p = \frac{70}{11}$$

12. Find the shortest distance between the lines

$$\frac{x+1}{7} = \frac{y+1}{-6} = \frac{z+1}{1} \text{ and } \frac{x-3}{1} = \frac{y-5}{-2} = \frac{z-7}{1}$$

Solution:

We know that Shortest distance between two lines (in

Cartesian form) $\frac{x-x_1}{l_1} = \frac{y-y_1}{m_1} = \frac{z-z_1}{n_1}$,

$\frac{x-x_2}{l_2} = \frac{y-y_2}{m_2} = \frac{z-z_2}{n_2}$ is given by

$$d = \frac{\begin{vmatrix} x_2 - x_1 & y_2 - y_1 & z_2 - z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix}}{\sqrt{(m_1n_2 - m_2n_1)^2 + (n_1l_2 - l_1n_2)^2 + (l_1m_2 - m_1l_2)^2}}.$$

Hence the required shortest distance is

$$\frac{\begin{vmatrix} 4 & 6 & 8 \\ 7 & -6 & 1 \\ 1 & -2 & 1 \end{vmatrix}}{\sqrt{(-6+2)^2 + (1-7)^2 + (-14+6)^2}} = 2\sqrt{29}$$

13. Find the distance of the plane $2x-3y+4z-6=0$ from the origin.

Solution:

Perpendicular distance of a point (x_1, y_1, z_1) from a plane $ax+by+cz+d=0$ is given by $\frac{|ax_1 + by_1 + cz_1 + d|}{\sqrt{a^2 + b^2 + c^2}}$

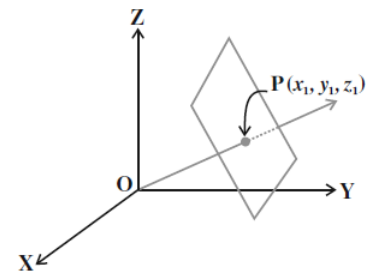
Hence,

Distance of origin $(0,0,0)$ from the plane $2x-3y+4z-6=0$ is given by

$$\frac{|0+0+0-6|}{\sqrt{2^2 + 3^2 + 4^2}} = \frac{6}{\sqrt{29}}$$

14. Find the coordinates of the foot of perpendicular drawn from the origin to the plane $2x-3y+4z-6=0$.

Solution:



Assume the foot of perpendicular P with coordinates (x_1, y_1, z_1) .

The direction ratios of $OP = \langle x_1, y_1, z_1 \rangle$

Let us write the equation of the plane in Normal Form as

$$\frac{2}{\sqrt{29}}x - \frac{3}{\sqrt{29}}y + \frac{4}{\sqrt{29}}z = \frac{6}{\sqrt{29}}$$

Obviously, the direction cosines of Normal to the plane

$$OP \text{ are } \frac{2}{\sqrt{29}}, -\frac{3}{\sqrt{29}}, \frac{4}{\sqrt{29}}$$

The direction cosines and direction ratios are proportional

$$\frac{x_1}{\frac{2}{\sqrt{29}}} = \frac{y_1}{\frac{-3}{\sqrt{29}}} = \frac{z_1}{\frac{4}{\sqrt{29}}} = k$$

$$\Rightarrow x_1 = \frac{2}{\sqrt{29}}k, y_1 = \frac{-3}{\sqrt{29}}k, z_1 = \frac{4}{\sqrt{29}}k$$

The point (x_1, y_1, z_1) is on the plane hence $2x_1 - 3y_1 + 4z_1 - 6 = 0$

On putting values of x_1, y_1, z_1 in the equation $k = \frac{6}{\sqrt{29}}$.

So the coordinates of P comes out to be $\left(\frac{12}{29}, -\frac{18}{29}, \frac{24}{29}\right)$

15. Find the equation of the plane passing through the intersection of the planes $x+y+z=6$ and $2x+3y+4z=-5$ and the point $(1,1,1)$.

Solution:

We know that the Equation of a plane passing through the intersection of two planes $ax+by+cz+d=0$ and $a'x+b'y+c'z+d'=0$ is given by $(ax+by+cz+d)+\lambda(a'x+b'y+c'z+d')=0$ where λ is a parameter whose value can be evaluated under given condition.

Similarly, The plane passing through the two given planes is

$$(x+y+z-6) + \lambda(2x+3y+4z+5) = 0$$

$$\Rightarrow (1+2\lambda)x + (1+3\lambda)y + (1+4\lambda)z + (5\lambda-6) = 0$$

This plane passes through $(1,1,1)$ so

$$(1+2\lambda) + (1+3\lambda) + (1+4\lambda) + (5\lambda-6) = 0$$

$$\Rightarrow \lambda = \frac{3}{14}$$

Therefore, the required plane is

$$20x+23y+26z=69$$

16. Show that the lines $\frac{x+3}{-3} = \frac{y-1}{1} = \frac{z-5}{5}$ and $\frac{x+1}{-1} = \frac{y-2}{2} = \frac{z-5}{5}$ are coplanar.

Solution:

We know that if the lines $\frac{x-x_1}{l_1} = \frac{y-y_1}{m_1} = \frac{z-z_1}{n_1}$, and

$\frac{x-x_2}{l_2} = \frac{y-y_2}{m_2} = \frac{z-z_2}{n_2}$ are coplanar (i.e. intersecting)

$$\text{then } \begin{vmatrix} x_2-x_1 & y_2-y_1 & z_2-z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0$$

Given $x_1=-3, y_1=1, z_1=5, x_2=-1, y_2=2, z_2=5, l_1=-3, m_1=1, n_1=5, l_2=-1, m_2=2, n_2=5$

$$\text{Hence, } \begin{vmatrix} x_2-x_1 & y_2-y_1 & z_2-z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix}$$

$$= \begin{vmatrix} -1+3 & 2-1 & 5-5 \\ -3 & 1 & 5 \\ -1 & 2 & 5 \end{vmatrix}$$

$$= \begin{vmatrix} 2 & 1 & 0 \\ -3 & 1 & 5 \\ -1 & 2 & 5 \end{vmatrix} = 2(5-10) - 1(-15+5)$$

$= -10+10=0$ hence the lines are coplanar.

17. Find the angle between the two planes $2x+y-2z=5$, and $3x-6y-2z=7$.

Solution:

We know that the angle between two planes: $a_1x + b_1y + c_1z + d_1=0$ and $a_2x + b_2y + c_2z + d_2=0$ is defined as the

angle between their normals and is given by

$$\cos \theta = \frac{a_1 a_2 + b_1 b_2 + c_1 c_2}{\sqrt{a_1^2 + b_1^2 + c_1^2} \sqrt{a_2^2 + b_2^2 + c_2^2}}.$$

Given $a_1=2, b_1=1, c_1=-2, a_2=3, b_2=-6, c_2=-2$

$$\text{Hence } \cos \theta = \frac{a_1 a_2 + b_1 b_2 + c_1 c_2}{\sqrt{a_1^2 + b_1^2 + c_1^2} \sqrt{a_2^2 + b_2^2 + c_2^2}}$$

$$\text{Or } \cos \theta = \frac{(2)(3) + (1)(-6) + (-2)(-2)}{\sqrt{4+1+4} \sqrt{9+36+4}}$$

$$\Rightarrow \cos \theta = \frac{6-6+4}{3 \times 7} = \frac{4}{21}$$

$$\Rightarrow \theta = \cos^{-1} \left(\frac{4}{21} \right)$$

18. Find the distance of a point (2,5,-3) from the plane $6x-3y+2z=4$.

Solution:

Perpendicular distance of a point (x_1, y_1, z_1) from a plane

$$ax+by+cz+d=0 \text{ is given by } \frac{|ax_1 + by_1 + cz_1 + d|}{\sqrt{a^2 + b^2 + c^2}}$$

$$\text{So the required distance} = \frac{|ax_1 + by_1 + cz_1 + d|}{\sqrt{a^2 + b^2 + c^2}}$$

$$= \frac{|(6)(2) + (-3)(5) + (2)(-3) - 4|}{\sqrt{36+9+4}}$$

$$= \frac{|12-15-6-4|}{7} = \frac{13}{7}$$

19. Find the angle between the line $\frac{x+1}{2} = \frac{y}{3} = \frac{z-3}{6}$

and the plane $10x+2y-11z=3$.

Solution:

The Angle between a line and a plane is defined as “the complement of the angle between the line and the normal

to the plane”. If the line is $\frac{x-x_1}{l} = \frac{y-y_1}{m} = \frac{z-z_1}{n}$ and

the plane is $ax+by+cz+d=0$, and θ is the angle between the line and the plane then it is given by

$$\sin \theta = \frac{al + bm + cn}{\sqrt{a^2 + b^2 + c^2} \sqrt{l^2 + m^2 + n^2}}.$$

Given $l=2, m=3, n=6, a=10, b=2, c=-11$

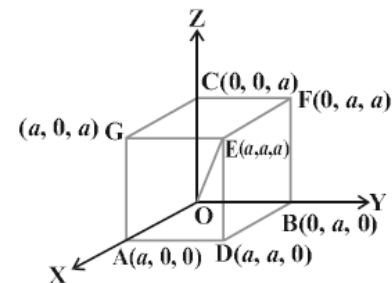
$$\begin{aligned} \sin \theta &= \frac{(10)(2) + (2)(3) + (-11)(6)}{\sqrt{100+4+121} \sqrt{4+9+36}} \\ &= \frac{20+6-66}{15 \times 7} = \frac{-40}{105} = -\frac{8}{21} \end{aligned}$$

20. A line makes angles $\alpha, \beta, \gamma, \delta$ with the diagonals of a cube, prove that

$$\cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma + \cos^2 \delta = \frac{4}{3}$$

Solution:

Assume a cube OADBFEGC,



The four diagonals are OE, AF, BG, CD

The direction cosines of OE are

$$\frac{a-0}{\sqrt{a^2+a^2+a^2}}, \frac{a-0}{\sqrt{a^2+a^2+a^2}}, \frac{a-0}{\sqrt{a^2+a^2+a^2}}$$

$$\text{Or } \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}$$

Similarly, dcs of AF are $-\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}$

$$\text{Dcs of BG are } \frac{1}{\sqrt{3}}, -\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}$$

$$\text{Dcs of CD are } \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, -\frac{1}{\sqrt{3}}$$

Let the dcs of the reuired line be l, m, n

$$\text{Then } \cos \alpha = \frac{l}{\sqrt{3}} + \frac{m}{\sqrt{3}} + \frac{n}{\sqrt{3}} \dots (i)$$

$$\cos \beta = -\frac{l}{\sqrt{3}} + \frac{m}{\sqrt{3}} + \frac{n}{\sqrt{3}} \dots (ii)$$

$$\cos \gamma = \frac{l}{\sqrt{3}} - \frac{m}{\sqrt{3}} + \frac{n}{\sqrt{3}} \dots (iii)$$

$$\cos \delta = \frac{l}{\sqrt{3}} + \frac{m}{\sqrt{3}} - \frac{n}{\sqrt{3}} \dots (iv)$$

$$\text{So, } \cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma + \cos^2 \delta$$

$$= \frac{l^2}{3} + \frac{m^2}{3} + \frac{n^2}{3} + \frac{2lm}{3} + \frac{2ln}{3} + \frac{2mn}{3}$$

$$+ \frac{l^2}{3} + \frac{m^2}{3} + \frac{n^2}{3} - \frac{2lm}{3} - \frac{2ln}{3} + \frac{2mn}{3}$$

$$+ \frac{l^2}{3} + \frac{m^2}{3} + \frac{n^2}{3} - \frac{2lm}{3} + \frac{2ln}{3} - \frac{2mn}{3}$$

$$+ \frac{l^2}{3} + \frac{m^2}{3} + \frac{n^2}{3} + \frac{2lm}{3} - \frac{2ln}{3} - \frac{2mn}{3}$$

$$= \frac{4l^2}{3} + \frac{4m^2}{3} + \frac{4n^2}{3} = \frac{4}{3}(l^2 + m^2 + n^2) = \frac{4}{3}$$

21. Find the equation of the plane that contains the point (1,-1,2) and is perpendicular to each of the planes $2x+3y-2z=5$, and $x+2y-3z=8$.

Solution:

Let the equation of the plane containing the given point be

$$A(x-1)+B(y+1)+C(z-2)=0 \dots (i)$$

The plane is perpendicular to the given planes,

$$2A+3B-2C=0 \dots (ii)$$

$$A+2B-3C=0 \dots (iii)$$

On solving (ii) and (iii) we get $A=-5C$, and $B=4C$,

Putting these values in (i)

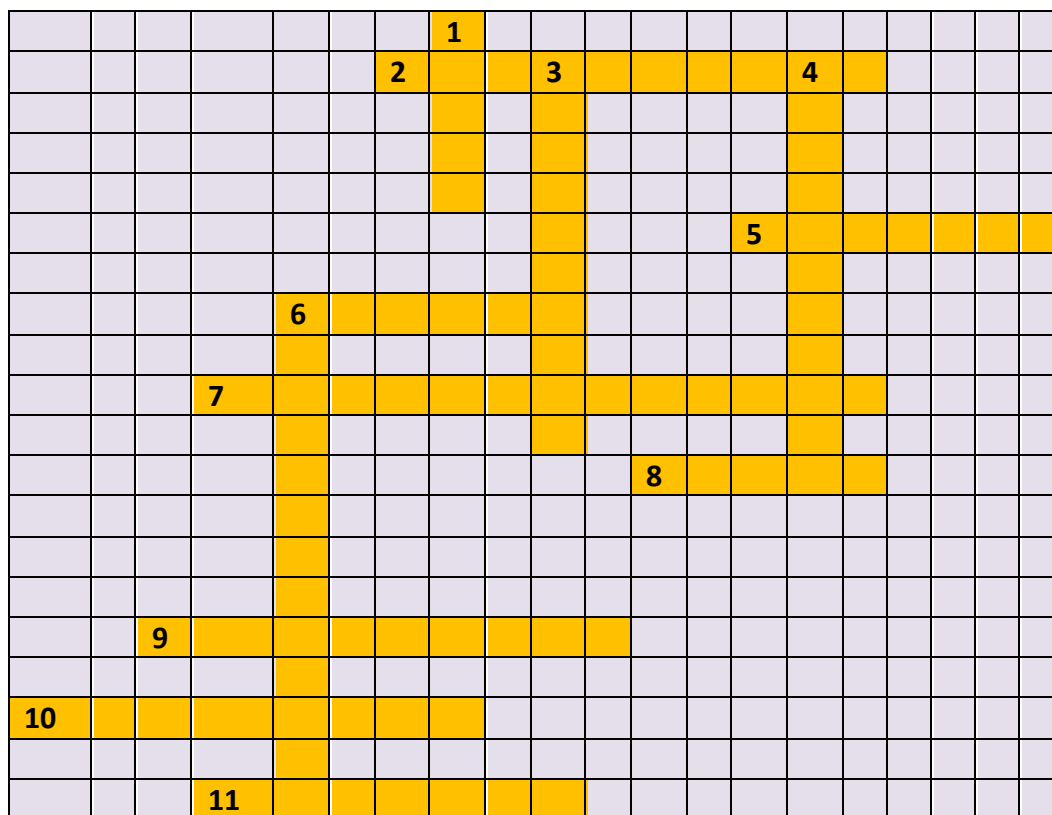
$$-5C(x-1)+4C(y+1)+C(z-2)=0$$

$$\text{Or, } -5x+4y+z=-5-4+2=-7 \text{ Or, } 5x-4y-z=7$$



Dr S.B. Dhar, is **Editor of this Quarterly e-Bulletin**. He is an eminent mentor, analyst and connoisseur of Mathematics from IIT for preparing aspirants of Competitive Examinations for Services & Admissions to different streams of study at Undergraduate and Graduate levels using formal methods of teaching shared with technological aids to keep learning at par with escalating standards of scholars and learners. He has authored numerous books of excellence.

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CROSSWORD PUZZLE: π **Prof. SB Dhar****Across**

- 2 Nature of π as a Number
- 5 Method's Name used by Fibonacci for π
- 6 Figure to which π is related basically
- 7 A number that is not algebraic
- 8 Name of Identity connecting e, i, π
- 9 Word for which π is an abbreviation in Greek
- 10 Nature of series used by Madhava-Leibniz to find π
- 11 Name of the point π is called in mathematical folklore

Down

- 1 π is taken from Alphabet of
- 3 Greek mathematician who evaluated π
- 4 Estimated value of $22/7$ is called
- 6 Perimeter of circle
- 9 Word for which π is an abbreviation in Greek

Next Issue is Quarterly, Due on 1st April'18.

It commemorates World Earth Day (विश्व पृथ्वी दिवस) celebrated annually on 22 April, since 1970, to demonstrate support for environmental protection.



Growing with Concepts : Physics

Inability to contribute, due to unavoidable reasons, for this column in this e-Bulletin is deeply regretted.

Dr. Subhash Joshi

—00—

Nature is an excellent example of unity in diversity. Atom at its basic constituent level, it comprises particles of different nature. Some of them are of opposite in nature, and experience a strong force of attraction, yet they continue to exist separately and individually; particles of similar nature, having strong force of repulsion continue to exist in vicinity. This has been there since beginning of nature, and shall continue to exist indefinitely. Any unregulated infringement on the other would be disastrous. The secret of coexistence is in respecting others position.

—00—

INVITATION FOR CONTRIBUTION OF ARTICLES

Your contribution in the form of an article, story poem or a narration of real life experience is of immense value to our students, the target audience, and elite readers of this Quarterly monthly e-Bulletin **Gyan-Vigyan Sarita: शिक्षा**, and thus create a visibility of the concerns of this initiative. It gives target students a feel that you care for them, and they are anxiously awaiting to get benefitted by your contributions. We request you to please feel free to send your creation, by **20th of this month** to enable us to incorporate your contribution in next bulletin, subhashjoshi2107@gmail.com.

We will be pleased have your association in taking forward path our plans as under-

- **With the start of Second year of operation, we have reached to 7th Quarterly e-Bulletin Gyan-Vigyan Sarita: शिक्षा, which shall be brought out 1st March'18.**
- **Theme of the e-Bulletin is **World Earth Day** (विश्व पृथ्वी दिवस) celebrated annually on 22 April, since 1970. It is, to demonstrate support for environmental protection**
- **And this cycle of monthly supplement sandwiching consecutive Quarterly e-Bulletin Gyan-Vigyan Sarita: शिक्षा is aimed to continue endlessly**

We believe that this monthly supplements to quarterly periodicity of e-Bulletins shall make it possible for our esteemed contributors to make contribution rich in content, diversity and based on their ground level work and/or experiences.

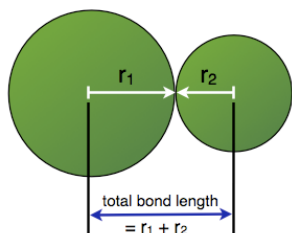
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Growing with Concepts: Chemistry

SOME IMPORTANT BOND CHARACTERISTICS (BOND PARAMETERS)

Kumud Bala

1. **Bond length:** Bond length is defined as the average distance between the centers of the nuclei of two bonded atoms in a molecule. Therefore, it represents equilibrium inter nuclear separation distance of the bonded atoms in a molecule.



(The bond length in a covalent molecule)

It is measured by spectroscopic, X-ray diffraction and electron diffraction techniques. Each atom of the bonded pair contributes to the bond length. In the case of covalent bond, the contribution from each atom is called the covalent radius of that atom. The covalent radius is measured approximately as the radius of an atom's core which is in contact with the core of an adjacent atom in a bonded situation. The covalent radius is half of the distance between two similar atoms joined by a covalent bond in the same molecule. Bond length is usually expressed in Angstrom units(\AA) or picometers (pm) ; $1 \text{ \AA} = 10^{-10}\text{m}$, $1\text{pm} = 10^{-12}\text{m}$

Factors affecting bond length:

(a) size of the atom: the bond length increases with increase in the size of the atoms. For example, bond lengths of H-X are in the order $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$

(b) Multiplicity of the bond: the bond length decreases with increase in multiplicity of bond. Thus, $\text{C}\equiv\text{C}$ bond length is shorter than $\text{C}=\text{C}$ bond which in turn is shorter than $\text{C}-\text{C}$ bond, i.e., $\text{C}\equiv\text{C} < \text{C}=\text{C} < \text{C}-\text{C}$. Similarly, $\text{N}\equiv\text{N} < \text{N}=\text{N} < \text{N}-\text{N}$ and $\text{O}=\text{O} < \text{O}-\text{O}$.

2. **Bond enthalpy (bond energy):** When atoms come close together resulting in the formation of bond between them, energy is released. This means

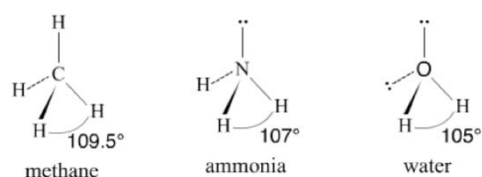
that the bonded atoms have lesser energy than the separated individual atoms. Obviously, the same amount of energy will be needed to break the bond. This is called bond dissociation energy and is measure of bond strength. "Bond dissociation enthalpy may be defined as the amount of energy required to break one mole of bonds of a particular type between the atoms in the gaseous state". It is generally expressed in terms of kJmol^{-1} . For example, the bond dissociation enthalpy of H-H bond in hydrogen molecules is 435.8kJmol^{-1} . $\text{H}_2(\text{g}) \rightarrow \text{H}(\text{g}) + \text{H}(\text{g}) \quad \Delta H^\circ = 435.8\text{kJmol}^{-1}$, $\text{Cl}_2(\text{g}) \rightarrow \text{Cl}(\text{g}) + \text{Cl}(\text{g}) \quad \Delta H^\circ = 242.5\text{kJmol}^{-1}$. It may be noted that larger the bond dissociation enthalpy, stronger will be the bond in the molecule.

Factors affecting bond enthalpy:- **(a)** size of the atom- the smaller the size of the bonded atoms, the stronger is the bond. Consequently, larger is the value of bond dissociation enthalpy. For example, bond dissociation enthalpy of H-H bond (435.8kJmol^{-1}) is larger than the bond dissociation enthalpy of Cl-Cl (242.5kJmol^{-1}). **(b)** bond length:- Shorter the bond length, larger is the value of bond enthalpy. For example, C-C bond length (154pm) is larger than C=C bond length (134pm). The bond dissociation enthalpy of C-C bond (433kJmol^{-1}) is smaller than that of C=C bond (619kJmol^{-1}). Bond dissociation enthalpy of H_2 , O_2 , N_2 are in the order $\text{H}-\text{H} < \text{O}=\text{O} < \text{N}\equiv\text{N}$. **(c)** number of lone pairs of electrons present:- Greater the number of lone pairs of electrons present on the bonded atoms, greater is the repulsion between the atoms and hence, lesser is the bond dissociation energy. For example,

Bond	C-C (in $\text{H}_3\text{C}-\text{CH}_3$)	N-N (in $\text{N}\equiv\text{N}$)	O-O	F-F
Lone pair of electrons on each atom	0	1	2	3
Bond enthalpy (kJmol^{-1})	348	163	146	139

Average bond enthalpy:- In case of polyatomic molecules, the measurement of bond strength is more complicated. For example, in case of H₂O molecule, the enthalpy needed to break the two O-H bonds is not the same. $\text{H}_2\text{O (g)} \rightarrow \text{H (g)} + \text{OH (g)}$ $\Delta H^\circ_1 = 502 \text{ kJmol}^{-1}$, $\text{OH (g)} \rightarrow \text{O (g)} + \text{H (g)}$ $\Delta H^\circ_2 = 427 \text{ kJmol}^{-1}$. The difference in the ΔH° value shows that the second O-H bond undergoes some change because of changed chemical environment. This is the reason for some difference in energy of the same O-H bond in different molecules like C₂H₅OH (ethanol) and water. Therefore, in polyatomic molecules the term average bond enthalpy is used. It is obtained by dividing total bond dissociation enthalpy by the number of bonds broken. For example, in case of H₂O, average bond enthalpy = $(502 + 427) / 2 = 464.5 \text{ kJmol}^{-1}$

- 3. Bond angle:** Bond angle may be defined as the angle between the orbitals containing bonding electron pairs around the central atom in a molecule. It is expressed in degree/ minute / second. Bond angle gives an idea about the distribution of orbitals around the central atom in a molecule and therefore, determines the shape of a molecule. For example, H-C-H bond angle in methane is 109.5°, the H-O-H bond angle in H₂O is 104.5° and H-N-H bond angle in ammonia 107°.



- 4. Bond order:** The bond order is defined as the number of bonds between two atoms in a molecule. For example, bond order in H₂ (with a single shared electron pair) is one, in O₂ (with two shared electron pairs) is two, in N₂ (with three shared electron pairs) is three.

Bond	Symbol	Bond Order	Example
Single	—	1	F ₂ $\text{:}\ddot{\text{F}}-\ddot{\text{F}}\text{:}$
Double	=	2	O ₂ $\text{:}\ddot{\text{O}}=\ddot{\text{O}}\text{:}$
Triple	≡	3	N ₂ $\text{:}\ddot{\text{N}}\equiv\ddot{\text{N}}\text{:}$

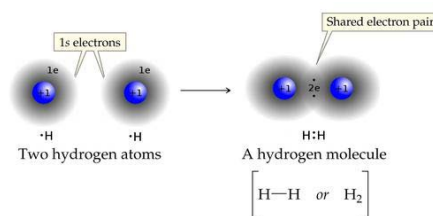
The bond order can be fractional also. For example, in odd electron molecules, the three electron bond is considered as equivalent to half covalent bond. Lewis structure of NO is -



Hence, its bond order is $2\frac{1}{2}$. It is interesting to observe that isoelectronic species have same bond order, for example, (i) F₂ and O₂²⁻ have 18 electrons each and each of them has a bond order equal to one. (ii) N₂, CO and NO⁺ have 14 electrons each and each of them has a bond order equal to three. Further, it is also observe that (i) greater the bond order, greater is the stability of the bond, i.e., greater is the bond enthalpy. (ii) greater the bond order, shorter is the bond length.

5. Polar and non-polar covalent bonds (polarity of bonds):

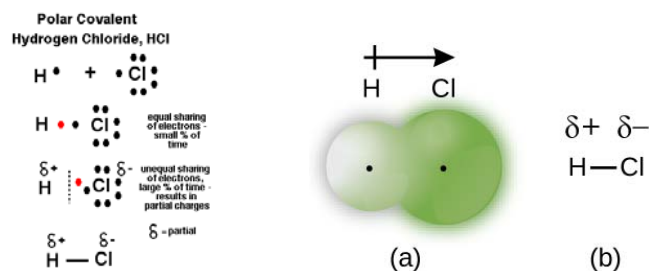
Non- polar covalent bonds:- If two similar atoms come close to each other and form a bond by sharing their electrons, the shared electrons are equally attracted by the two atoms as the electronegativity of the atoms is same. As a result, the shared electrons are not displaced towards any one atom. Hence, no poles are developed. This leads to the formation of completely non-polar bond. For example, if two hydrogen atoms form a bond, the electron pair will lie exactly in the middle between the two atoms and the resultant bond is non-polar.



The important characteristic of a non-polar bond is that the electron cloud is completely symmetrical and there is no charge separation at all. The examples of some non-polar molecules are Cl₂, O₂ and N₂ etc.

Polar covalent bonds:- When two dissimilar atoms having different electronegativities combine together to form a covalent bond, the shared pair of electrons does not lie at equal distance from the nuclei of both the bonded atoms but shifts towards

the atom having greater electronegativity. Since the more electronegative atom attracts the electrons more strongly, the distribution of electrons gets distorted, i.e., the electron cloud is displaced more towards the more electronegative atom. As a result, one end of the molecule, having more electronegative atom becomes slightly negatively charged while the other end acquires slightly positive charge. Thus, positive and negative poles are developed. Such molecules having two oppositely charged poles are called polar molecules and the bond is said to be polar covalent bond. The magnitude of electronegativity difference reflects the degree of polarity. Greater is the difference in the electronegativity of the atoms forming bond, greater will be the charge separation and hence greater will be the polarity of the molecule. For example, let us consider the case of hydrogen chloride molecule, chlorine is more electronegative than hydrogen. So the force of attraction, on the shared pair exerted by chlorine is more than that of hydrogen. Hence, it will be shifted towards chlorine, i.e., electron density of the electron cloud is more concentrated on chlorine side than on the hydrogen side. Consequently, chlorine becomes slightly negative charged and hydrogen becomes slightly positive charged.



6. Partial ionic character of covalent bonds:

As we know that two atoms linked together have different electronegativities, the bond formed is polar. In other words, the bond is said to possess partial ionic character. The extent of partial ionic character is determined by the difference in electronegativities of the combining atoms. More is the difference in electronegativities, greater will be the ionic character. If the electronegativity difference between two atoms is 1.9, the bond is said to have 50% ionic character and 50% covalent character. If the electronegativity difference between the two atoms is more than 1.9, the partial ionic character of the bond is more than 50% and the bond is taken as ionic. If the electronegativity

difference between two atoms is less than 1.9, the bond is predominantly covalent.

Electronegativity difference	0.2	0.6	0.8	1.2	1.9	2.2	2.8	3.2
Percent ionic character	1	10	15	30	50	70	86	92

Several empirical equations have been proposed to calculate the percentage ionic character from the electronegativity difference ($\chi_A - \chi_B$) of the bonded atoms. Two such equations are: (i) Pauling equation:- % ionic character = $[1 - e^{-1/4(\chi_A - \chi_B)}] \times 100$ or % ionic character = $18(\chi_A - \chi_B)^{1.4}$ (ii) Hannay and Smith equation: % ionic character = $16(\chi_A - \chi_B) + 3.5(\chi_A - \chi_B)^2$

Example using Hannay and Smith equation:

calculate the percent ionic character of H-F bond. Electronegativities $\chi_H = 2.1$, $\chi_F = 4.0$. Solution-
% ionic character = $16(\chi_F - \chi_H) + 3.5(\chi_F - \chi_H)^2 = 16(4.0 - 2.1) + 3.5(4.0 - 2.1)^2 = 16 \times 1.9 + 3.5(1.9)^2 = 30.4 + 12.635 = 43.035\%$.

7. **Dipole moment:-** We know that in a polar molecule, one end of the molecule is negative and the other is positive. In other words, there are two poles present in the molecule. Hence, the molecule is said to possess an electric dipole. Further, since the molecule as a whole is electrically neutral, the negative charge is always equal to the positive charge. The degree of polarity in the molecule is expressed by a term known as dipole moment. "Dipole moment is defined as the product of magnitude of negative or positive charge (q) and separation (r) between the charges". It is usually represented by Greek letter ' μ '. Mathematically, dipole moment = charge (q) \times distance of separation (r)

$$\mu = qr$$

q = charge on any of the atom and r = distance between the atoms.

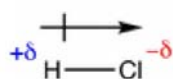
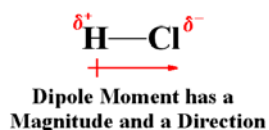
If the charge (q) is of the order of 10^{10} esu and the inter nuclear distance (r) is of the order of 10^{-8} cm, then the dipole moment ' μ ' will be of the order of $10^{10} \times 10^{-8} = 10^{-18}$ esu.cm. or = 1 Debye, denoted by the symbol D. Thus, $1D = 1 \times 10^{-18}$ esu.cm. For

example, the dipole moment of HCl molecule is 1.03D and that of H₂O is 1.85D. In SI units, dipole moment is expressed in the units of Coulomb-meter (Cm) ; as $1\text{esu} = \frac{1.602 \times 10^{-19}}{4.803 \times 10^{-10}} = 3.335 \times 10^{-10}\text{C}$, $1\text{cm} = 10^{-2}\text{m}$

$1\text{D} = 10^{-18}\text{esu} \cdot \text{cm} = 10^{-18} \times 3.335 \times 10^{-10}\text{C} \times 10^{-2}\text{m} = 3.335 \times 10^{-30}\text{Cm}$, Dipole moment is a vector quantity and is represented by a small arrow with tail at the positive centre and head pointing towards the negative centre.



For example, the dipole moment of HCl may be represented as:



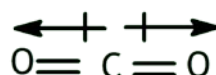
The shift in electron density is symbolized by crossed arrow (\longleftrightarrow) above the Lewis structure to indicate the direction of the shift.

Dipole moment and molecular structure:

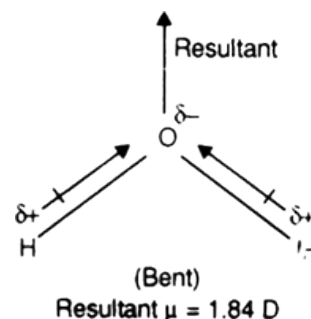
(a) Diatomic molecules: As a polar diatomic molecule possesses only one polar bond, the dipole moment of that molecule is equal to the dipole moment of the polar bond, e.g., in case of HCl, the molecular dipole moment is equal to the dipole moment of H-Cl bond, i.e., 1.07D. Greater the electronegativity difference between the bonded atoms, greater is the dipole moment. For example, dipole moments of hydrogen halides are in the order: H-F (1.78D) > H-Cl (1.07D) > H-Br (0.79D) > H-I (0.38D)

(b) Polyatomic molecules: As polyatomic molecule has more than one polar bonds, the dipole moment is equal to the resultant dipole moment of all the individual bonds. The magnitude of this resultant dipole moment not only depends upon the values of the individual dipole moments of the bonds but also on their arrangement in space. For example, carbon dioxide (CO₂) and water (H₂O) are both triatomic molecules but

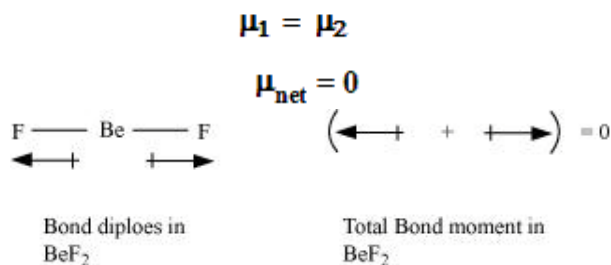
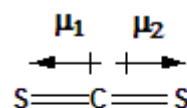
dipole moment of carbon dioxide is zero where as that of H₂O is 1.84D. This can be explained on the basis of their structures. Carbon dioxide is a linear molecule in which the two C=O bonds are oriented in the opposite directions at an angle of 180°. The dipole moment of each C=O bond is 2.3D but due to linear geometry of CO₂, the dipole moment of one C=O bond cancels that of another. Therefore, the resultant dipole moment of the molecule is zero.



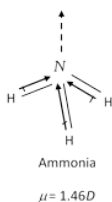
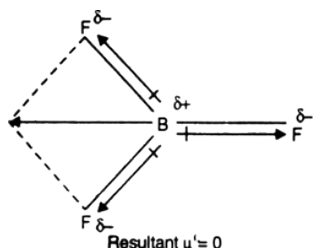
$\mu = 0$ hence, CO₂ is a non-polar molecule. On the other hand, water molecule has a bent structure in which the two O-H bonds are oriented at an angle of 104.5°. The resultant dipole moment of two O-H bonds of water is 1.84D.



Dipole moments of BeF₂ and CS₂ are also zero. This is because the molecules are linear and the equal bond dipoles point in opposite directions. These bond dipoles cancel the effect of each other giving a net zero dipole moment.



Let us consider tetra-atomic molecules such as BF_3 and NH_3 . The dipole moment of BF_3 molecule is zero while that of NH_3 is 1.47D. This suggests that BF_3 molecule has symmetrical structure in which the three B-F bonds are oriented at an angle of 120° to one another. The three bonds lie in one plane and the dipole moments of these bonds cancel one another giving net dipole moment equal to zero. On the other hand, the ammonia molecule has pyramidal structure. The individual bond dipole moments of three N-H bonds give the resultant dipole moment of NH_3 molecule as 1.47D.



Importance of dipole moment:- Dipole moment plays very important role in understanding the nature of chemical bond. A few applications are given below:

1. Distinction between polar and non-polar molecules- The measurement of dipole moment can help us to distinguish between polar and non-polar molecules. Non polar molecules have zero dipole moment while polar molecules have some finite value of dipole moment. For example, H_2 molecule with zero dipole moment is non-polar molecule while HCl molecule having dipole moment of 1.07D is a polar molecule.
2. Degree of polarity in a molecule- Dipole moment measurement also gives an idea about the degree of polarity especially in a diatomic molecule. The greater the dipole moment, the greater is the polarity in such a molecule. For example, HF (1.78D) is more polar than HCl (1.07D).
3. Shapes of molecules- In case of molecules containing more than two atoms, the dipole moments not only depend upon the individual dipole moments of the bonds but also on the arrangement of bonds. Thus, dipole moment is used to find the shapes of molecules. For example, the dipole moment of water is 1.85D while that of carbon dioxide is zero. This means that carbon dioxide is a linear molecule in which the individual dipole moments of two CO

bonds cancel each other. On other hand, water is not linear but it has angular shape, having the resultant dipole moment of two bond dipoles as 1.85D.

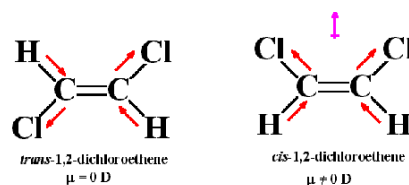
4. In the calculation of percentage ionic character- The percentage of ionic character can be calculated from the ratio of the observed dipole moment to the dipole moment for the complete electron transfer (100% ionic character). For example, in HCl molecule, the observed dipole moment is 1.07D and its bond length is 1.275 \AA . Assuming 100% ionic character, the charge developed on H and Cl atoms would be $4.8 \times 10^{-10} \text{ esu}$. Therefore, dipole moment for 100% ionic character will be

$$\mu_{\text{ionic}} = q \times r = 4.8 \times 10^{-10} \text{ e.s.u.} \times 1.275 \times 10^{-8} \text{ cm} = 6.12 \times 10^{-18} \text{ esu cm} = 6.12\text{D},$$

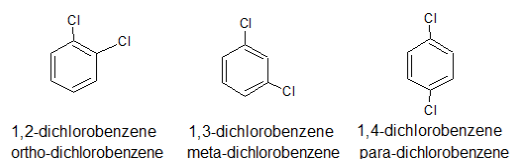
$$\mu_{\text{observed}} = 1.07\text{D (given)}$$

$$\therefore \% \text{ ionic character} = \frac{\mu(\text{observed})}{\mu(\text{ionic})} \times 100 = \frac{1.07}{6.12} \times 100 = 17.48\%$$

5. Distinguishes between cis and trans-isomers:- Dipole moment measurement helps to distinguish between cis-isomer and trans-isomers because cis-isomer has usually higher dipole moment than trans-isomer. For example, in trans-isomer of 1,2-dichloroethene, the dipole moment is less because the bond moments of C-Cl bonds cancel each other.



6. Distinguishes between ortho, meta and para-isomers:- Dipole moment measurement helps to distinguish between o-, m-, p-isomers because the dipole moment of p-isomer is zero and that of o-isomer is more than that of m-isomer. For example,



$$\mu = 2.54\text{D}$$

$$\mu = 1.48\text{D}$$

$$\mu = 0$$

Example1:- Calculate the percentage ionic and covalent character of HF molecule having bond distance = 0.92\AA and dipole moment = 1.78D

Solution:- Dipole moment of the molecule assuming 100% ionic character: $\mu_{\text{ionic}} = q \times r = 4.8 \times 10^{-10} \text{ esu} \times 0.92 \times 10^{-8} \text{ cm} = 4.416 \times 10^{-18} \text{ esu.cm} = 4.416\text{D}$, $\mu_{\text{observed}} = 1.78\text{D}$

$$\% \text{ ionic character} = \frac{\mu(\text{observed})}{\mu(\text{ionic})} \times 100 = \frac{1.78\text{D}}{4.416\text{D}} \times 100 = 40.3\%$$

$$\% \text{ covalent character} = 100 - 40.3 = 59.7\%$$

Example2:- The dipole moment of HBr molecule is 0.78D and the bond distance is 1.41\AA . Calculate the fractional charges δ on H and Br atoms in HBr (electronic charge, $e = 4.8 \times 10^{-10} \text{ esu}$)

Solution:- Dipole moment (μ) = $q \times r$

$$\mu = 0.78\text{D} = 0.78 \times 10^{-18} \text{ esu.cm}, \quad r = 1.41 \times 10^{-8} \text{ cm}$$

$$\therefore q = \mu/r = 0.78 \times 10^{-18} \text{ esu.cm} / 1.41 \times 10^{-8} \text{ cm} = 0.55 \times 10^{-10} \text{ esu}$$

$$\text{Now, fraction of charge } (\delta) = \frac{\text{charge present}}{\text{electronic charge}} = \frac{q}{e} = \frac{0.55 \times 10^{-10} \text{ esu}}{4.8 \times 10^{-10} \text{ esu}} = 0.11$$

$$\therefore \text{H}^{+\delta} = 0.11 \quad \text{and} \quad \text{Br}^{-\delta} = -0.11$$

Assignment

- Which molecule is polar in each of the following pairs? (i) HF, F₂ (ii) CO₂, H₂O (iii) N₂, NH₃ (iv) CH₄, CH₃Cl
- Which of the following molecules have electric dipoles? (i) CCl₄ (ii) CHCl₃ (iii) CH₂Cl₂ (iv) CH₄
- Which of the following hydrogen halides has the most polar bond? (i) HF (ii) HCl (iii) HBr (iv) HI
- Predict the dipole moment of: (i) a molecule of the type AX₂ having a linear geometry (ii) a molecule of the type AX₄ having tetrahedral geometry (iii) a molecule of the type AX₂ having angular geometry (iv) a molecule of the type AX₄ having square planar geometry.

4. (i) zero (ii) zero (iii) appreciable dipole moment (iv) zero

3. (i) HF
2. (ii) CHCl₃ (iii) CH₂Cl₂ (iv) CH₃Cl
1. (i) HF (ii) H₂O (iii) NH₃ (iv) CH₃Cl

ANSWERS:

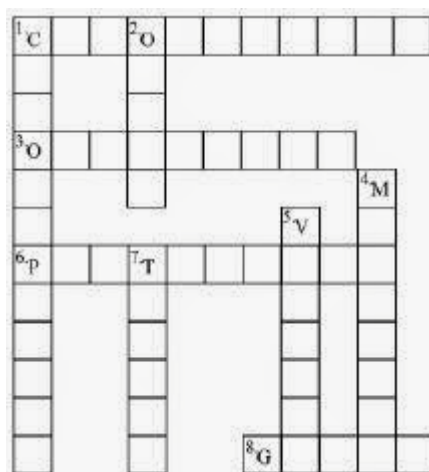


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Answers to Science Quiz (Crossword Puzzle) : Feb'18

Kumud Bala



—00—

I have been impressed with the urgency of doing. Knowing is not enough; we must apply. Being willing is not enough; we must do.

- Leonardo da Vinci

My ideal indeed can be put into a few words and that is: to preach unto mankind their divinity and how to make it manifest in every movement of life.

-Swami Vivekananda

—00—

Every day I remind myself that my inner and outer life are based on the labors of other men, living and dead, and that I must exert myself in order to give in the same measure as I have received and am still receiving.

- Albert Einstein

SCIENCE QUIZ: March'18

Kumud Bala

1. Which of the following is matter-
 - (i) Love
 - (ii) Almond
 - (iii) Cold
 - (iv) Thought
2. Naphthalene balls disappear with time without leaving any solid because of-
 - (i) Sublimation
 - (ii) Evaporation
 - (iii) Melting
 - (iv) Cooling
3. The increasing order of force of attraction between the particles of water, sugar and oxygen is-
 - (i) Sugar < Water < Oxygen
 - (ii) Oxygen < Water < Sugar
 - (iii) Water < Oxygen < Sugar
 - (iv) Sugar < Oxygen < Water.
4. Physical state of water at 25°C? is-
 - (i) Solid state
 - (ii) Both solid and liquid state
 - (iii) Liquid state
 - (v) B both liquid and gaseous
5. The more serious burn is produced by -
 - (i) Boiling water
 - (ii) Ice
 - (iii) Steam
 - (iv) Water vapours
6. The Tyndall effect is shown by?
 - (i) Salt solution
 - (ii) Copper sulphate solution
 - (iii) Starch solution
 - (iv) Water
7. Mass of oxygen atoms is-
 - (i) 3.2u
 - (ii) 4.2u
 - (iii) 2.2u
 - (iv) 5.2u
8. The numbers of molecules of sulphur (S₈) present in 16 g of solid sulphur is-
 - (i) 3.76×10^{22} molecules
 - (ii) 37.6×10^{22} molecules
 - (iii) 3.76×10^{23} molecules
 - (iv) 3.76×10^{21} molecules
9. Moles present in 20g of water is-
 - (i) 2.22g
 - (ii) 1.11g
 - (iii) 3.33g
 - (iv) 4.44g
10. The identity of an element is determined by-
 - (i) The number of its protons
 - (ii) The number of its neutrons
 - (iii) The number of its electrons
 - (iv) Its atomic mass.
11. When Fluorine atoms form chemical compound with metals, they tend to-
 - (i) Lose electrons
 - (ii) Gain electrons
 - (iii) Neither lose nor gain electrons
 - (iv) Fluorine is an inert gas
12. In Rutherford's experiment, α -particles were deflected because of-
 - (i) Electrostatic repulsion between α -particles and positively charged part of atom
 - (ii) Electrostatic attraction between α -particles and positively charged part of atom
 - (iii) Electrostatic repulsion between β -particles and positively charged part of atom
 - (iv) Electrostatic attraction between γ -particles and positively charged part of atom.
13. Energy of an electron in orbit is proportional to -
 - (i) Distance between shells
 - (ii) Distance from nucleus
 - (iii) Distance between two nuclei
 - (iv) Positive charge inside nucleus.
14. According to Rutherford, most of space occupied by atom is-
 - (i) Filled
 - (ii) Partially filled
 - (iii) Empty
 - (iv) None of these.
15. Electrons are embedded in a positive sphere was proposed by-
 - (i) E. Goldstein
 - (ii) Rutherford
 - (iii) J.J. Thomson
 - (iv) Bohr.

**(Answers to this Science Quiz Marh'18 shall be provided in
7th Quarterly e-Bulletin dt. 1st April'18)**

Theme Song :

PREMISE: We are pleased to adopt a song “ इतनीशक्तिहमेंदेनादाता” from a old Hindi Movie *Do Aankhen Barah Haath* दोआँखेंबारहहाथ of year 1957, directed by The Late V. Shantaram. The lyrics are by Shri Bharat Vyas, singer Melody Queen Sushri Lata Mangeshkar, and Music Direction by Vasant Desai. It has become a widely accepted inspirational song and/or prayer in many educational institutions and socially inspired initiatives engaged in mentoring of unprivileged children. This newly formed non-organizational initiative, being selflessly operated by a small set of compassionate persons, finds its philosophy in tune with the song and conveys its gratitude to all the eminent persons who brought out the song in a manner that it has attained an epitome of popularity. While working its mission and passion, the group invites one and all to collectively complement in grooming competence to compete among unprivileged children. The song/prayer goes as under -

इतनीशक्तिहमेंदेनादाता, मनकाविश्वासकमजोरहोना

हमचलेनेकरस्तेपेहमसे, भूलकरभीकोईभूलहोना ॥

दूरअज्ञानकेहोअंधेरे, तूहमेंज्ञानकीरोशनीदे

हरबुराईसेबचतेरहेहम, जितनीभीदेभलीज़िन्दगीदे

बैरहोनाकिसीकाकिसीसे, भावनामनमेंबदलेकीहोना ॥

इतनीशक्तिहमेंदेनादाता, मनकाविश्वासकमजोरहोना

हमचलेनेकरस्तेपेहमसे, भूलकरभीकोईभूलहोना ॥

हमनासोचेंहमेंक्यामिलाहै, हमयेसोचेकियाक्याहैअर्पण

फूलखुशियोंकेबाँटेसभीको, सबकाजीवनहीबनजाएमधुबन

अपनीकरुणाकाजलतूबहाके, करदेपावनहरएकमनकाकोना ॥

इतनीशक्तिहमेंदेनादाता, मनकाविश्वासकमजोरहोना

हमचलेनेकरस्तेपेहमसे, भूलकरभीकोईभूलहोना ॥



**Together Each Achieves More
(TEAM)**

Every end, so also end of this e-Bulletin, is a pause for a review, before resuming of the journey far beyond ...