HINDUSTHAN

COLLEGE OF ENGINEERING AND TECHNOLOGY

HIMAG

Institute Annual Magazine

2024 – 25

Volume XXI

HINDUSTHAN

COLLEGE OF ENGINEERING AND TECHNOLOGY

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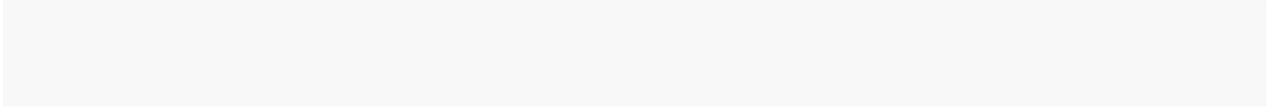
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EDITORIAL BOARD
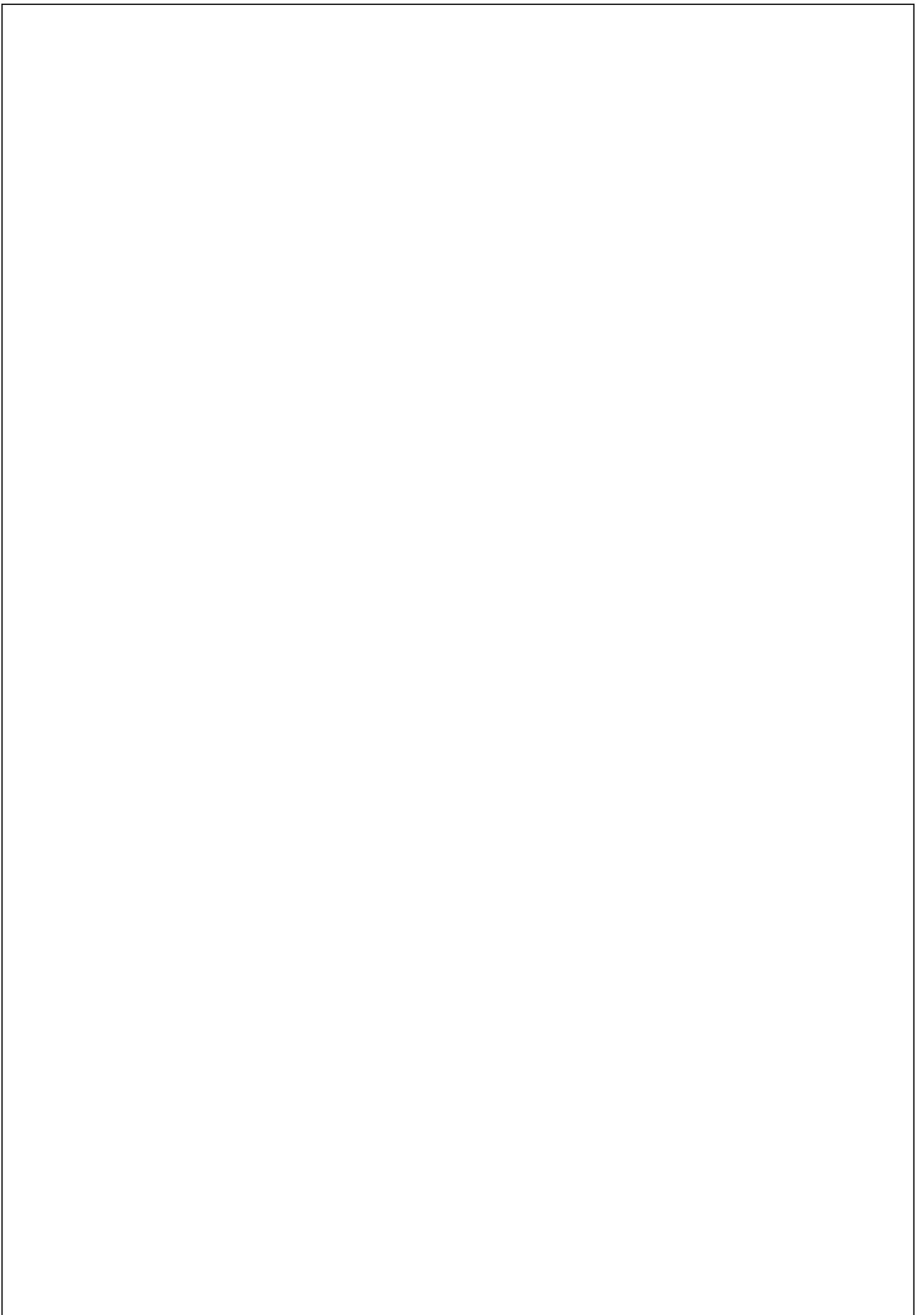
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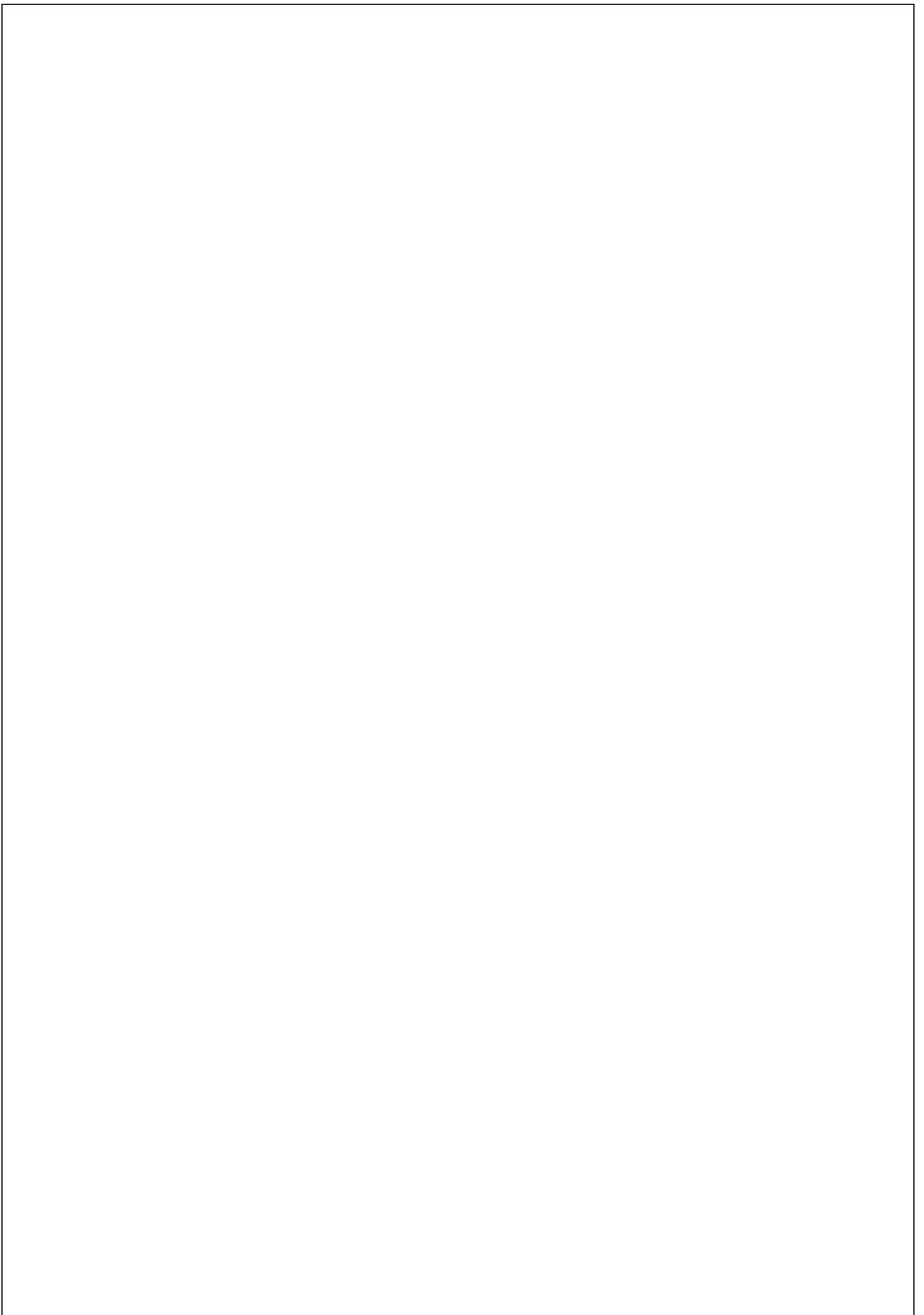
HINDUSTHAN COLLEGE OF ENGINEERING AND TECHNOLOGY

VISION

To become a premier Institution by producing professionals with strong technical knowledge, innovative research skills and high ethical values.

MISSION

IM1: To provide academic excellence in technical education through novel teaching methods.

IM2: To empower students with creative skills and leadership qualities.

IM3: To produce dedicated professionals with social responsibility.

QUALITY POLICY

Hindusthan College of Engineering and Technology (HiCET) aims at providing the best education which will mould the students as the right characters, who will cater to the needs of the society. While providing various inputs for the best education, HiCET constantly thrives upon continual improvement with the utmost commitment for the complete satisfaction of the stakeholders.
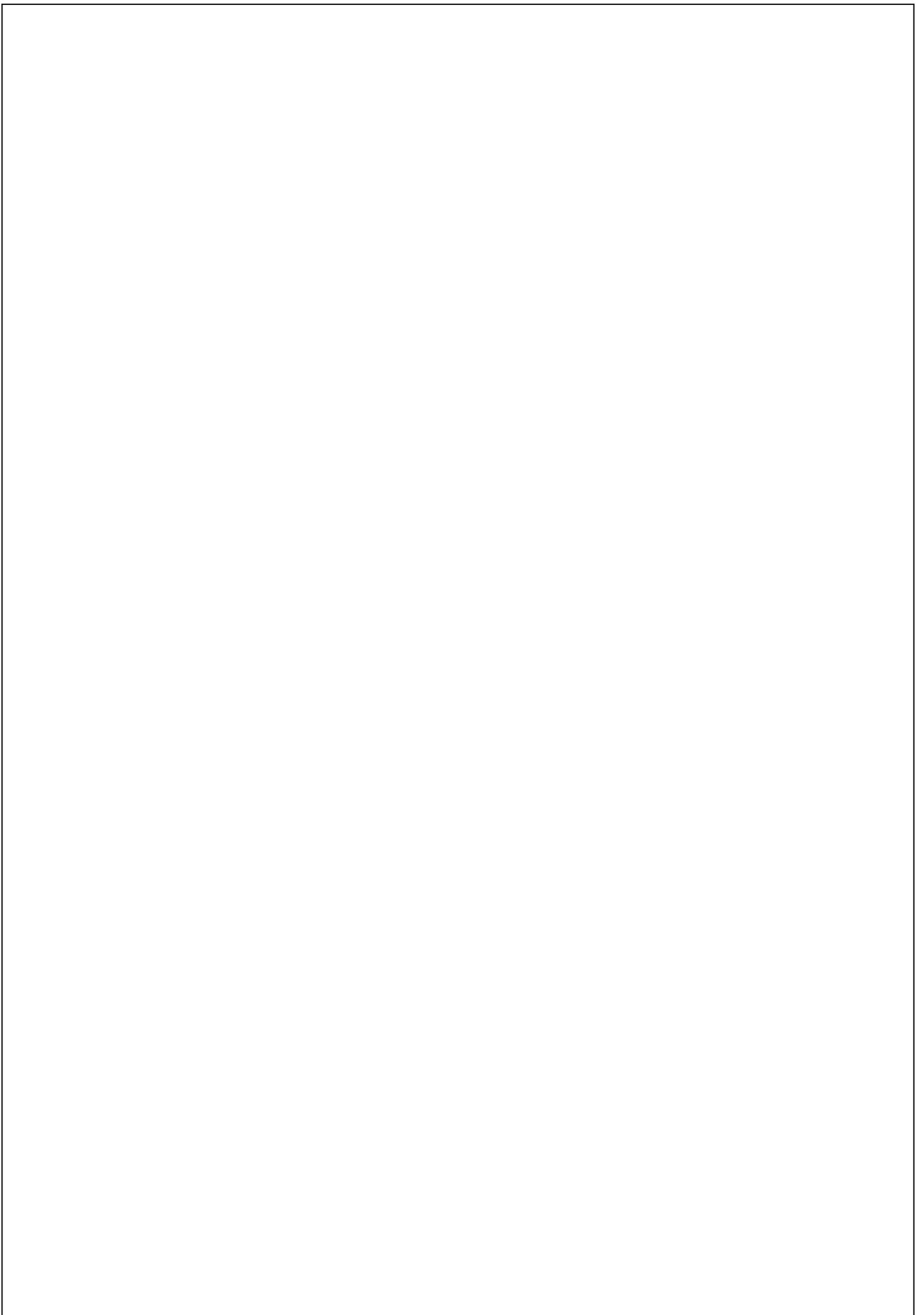
Principal's DESK

It gives me immense pleasure to present the Academic Year Magazine 2024–2025, a vibrant reflection of the intellectual and creative spirit of our institution. This publication stands as a testament to the collective achievements of our students and faculty, showcasing their literary expression, innovative thinking, and commitment to holistic growth.

An institute thrives not only through academic pursuits but also through its ability to nurture imagination, critical thought, and collaboration. This magazine captures those very ideals, offering a platform for our academic community to share

knowledge, inspire one another, and celebrate accomplishments across disciplines.

I extend my heartfelt appreciation to the editorial team for their dedication and meticulous efforts in bringing this edition to life. I am confident that this magazine will continue to inspire and serve as a lasting record of the vibrancy and excellence that define Hindusthan College of Engineering and Technology.

My best wishes to all contributors and readers.

Dr. J Jaya
Principal / HICET

PICTURE ART
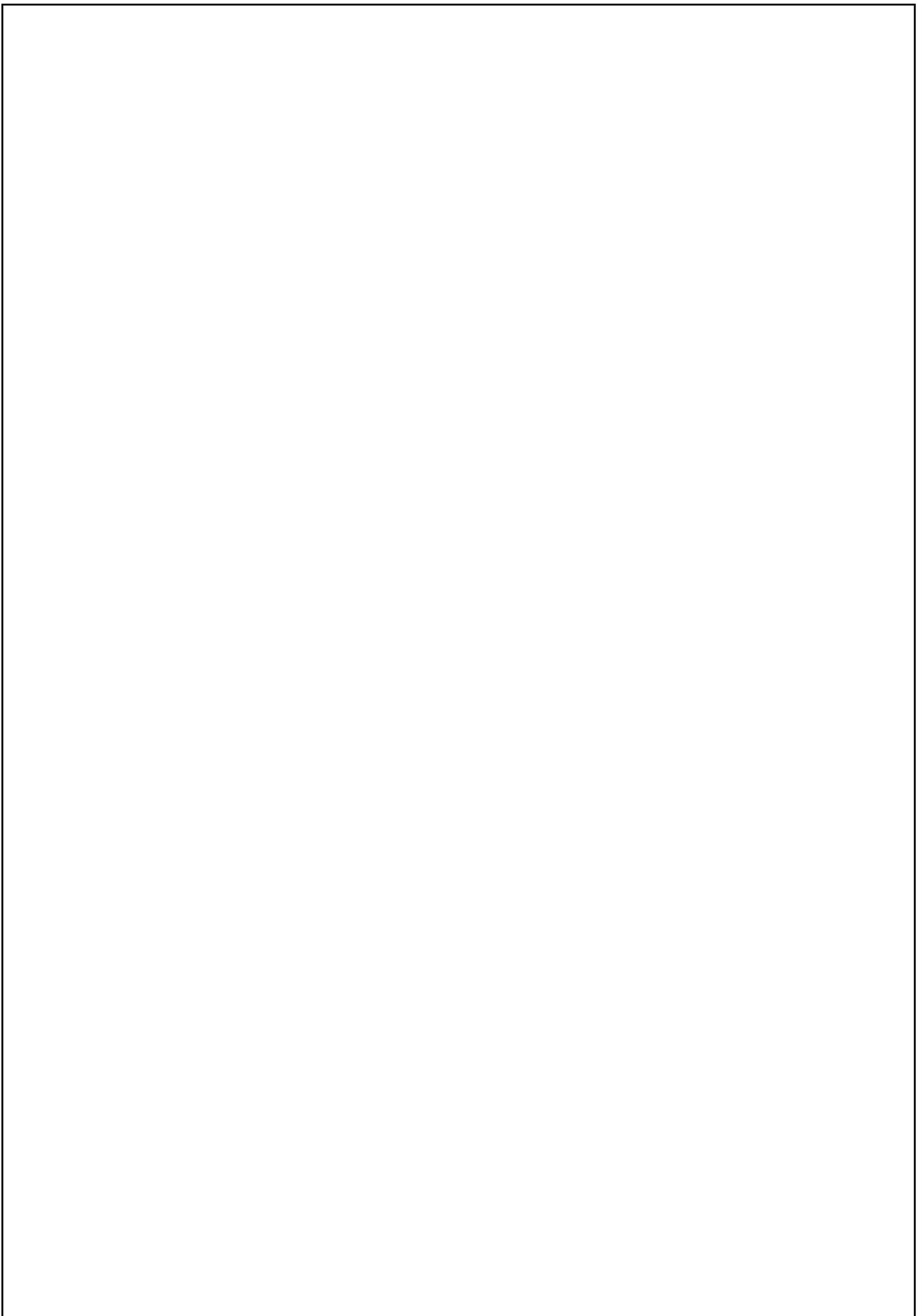
Mr V SHAMUGAM, III YEAR CIVIL ENGINEERING

Ms DEEPA, I YEAR AERONAUTICAL ENGG.,
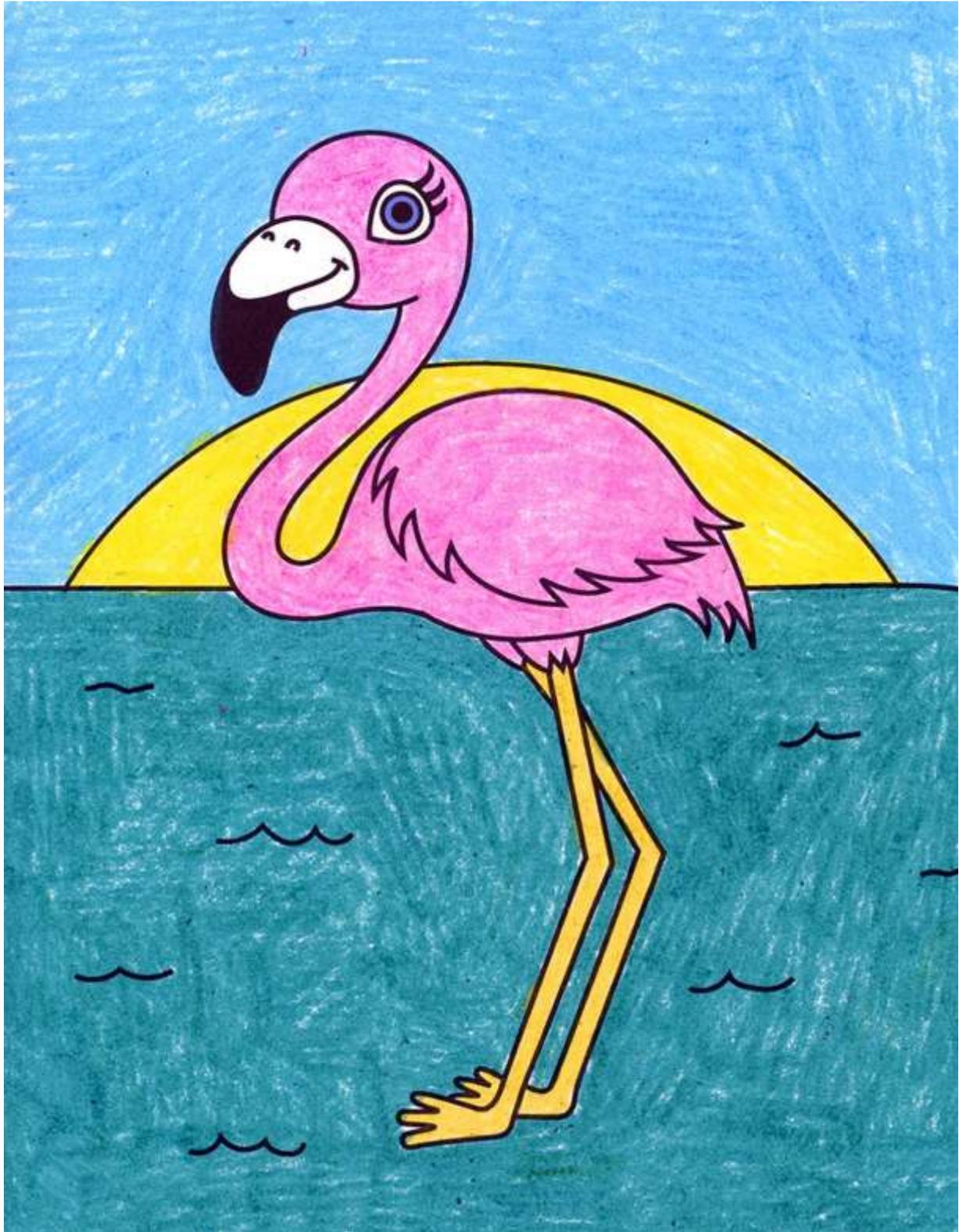
Ms AYANA P U, II YEAR AGRICULTURAL ENGG.,

Ms S KARITHIKA, II YEAR AUTOMOBILE ENGG.,
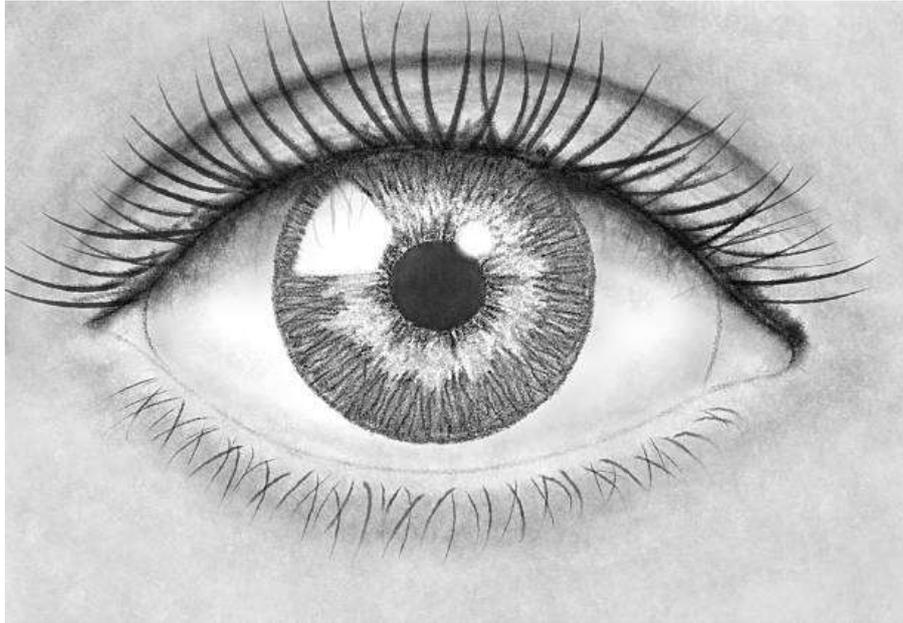
Mr V KAVINKUMAR III YEAR BIOMEDICAL ENGG.,

Mr U ARYA III YEAR CHEMICAL ENGG.,

Mr D HARISH IV YEAR CSE

Mr S DHILEEPAN S, III YEAR ECE

Mr N ARJUN, II YEAR IT

Mr M PRADEEP, III YEAR MECHANICAL
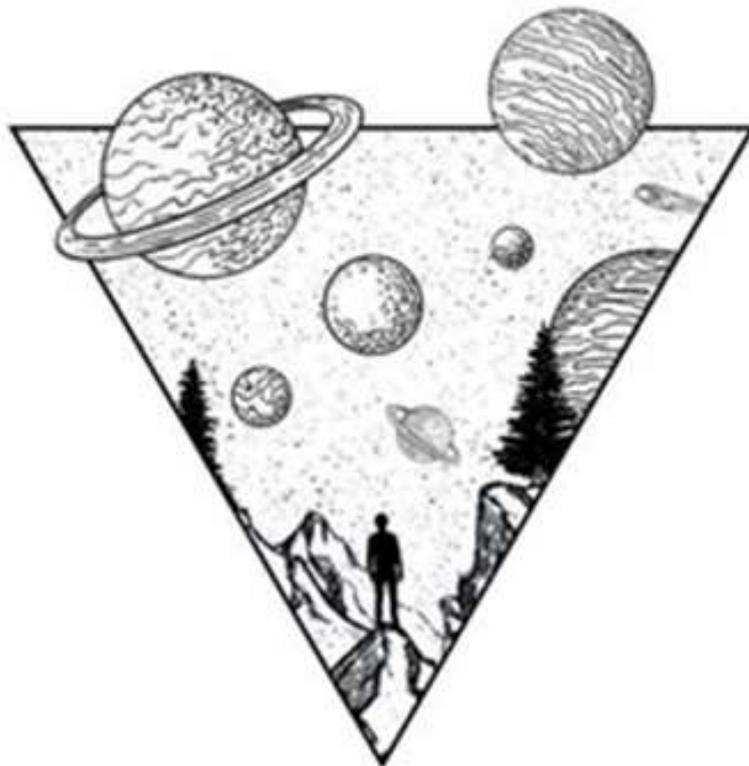
Mr M GOPALASAMY, III YEAR MECHANICAL

Mr C JEEVANAKESH, III YEAR AI & ML

PHOTOGRAPHY
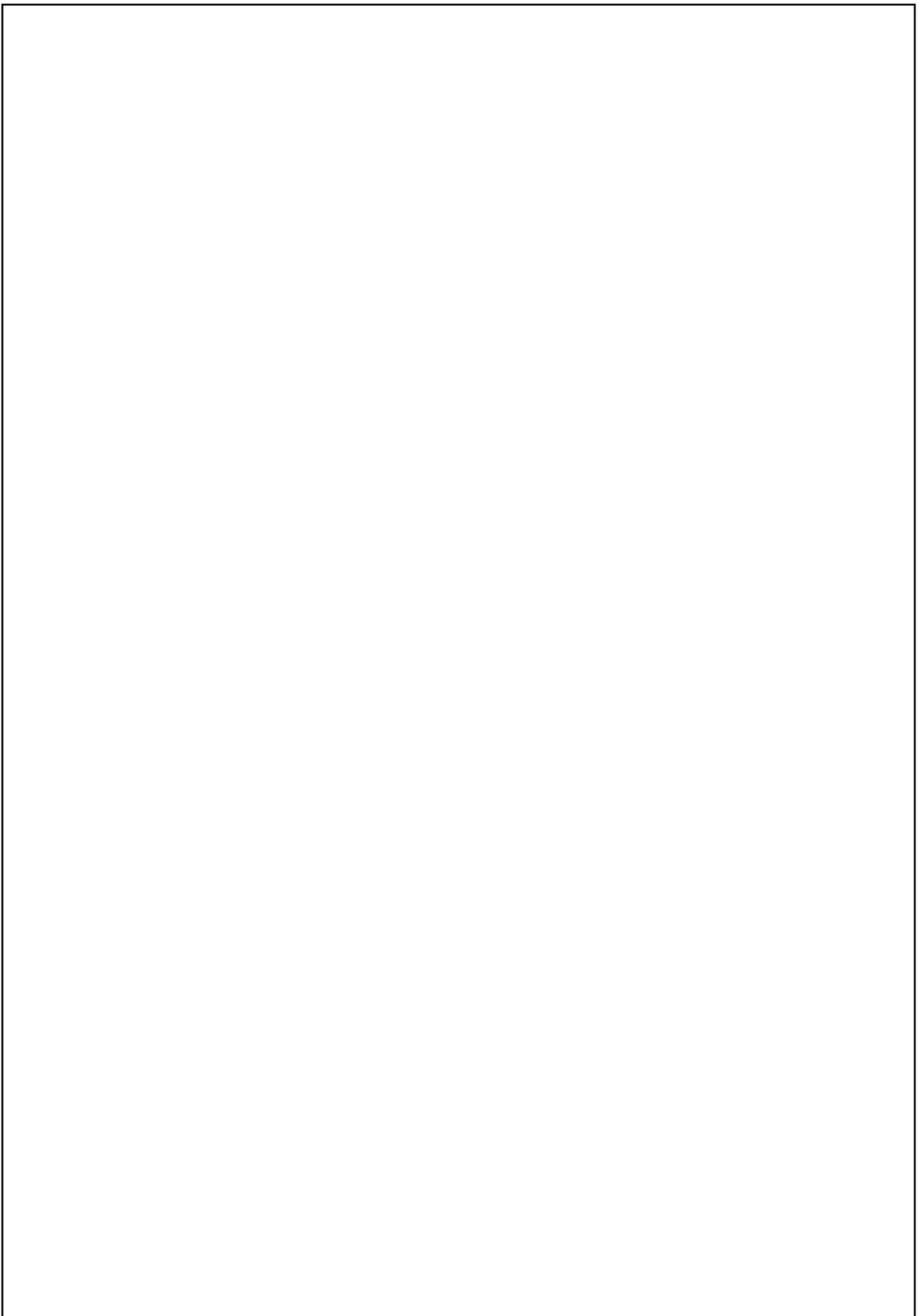
Mr P ARUNKUMAR, IV YEAR AERO

Mr R HARISWAR, III YEAR AUTO

Mr A DHANUSH, III YEAR CHEMICAL ENGG.,

Mr K BALAJI, III YEAR CIVIL

Mr P ARJUN

Mr C GANESH, III YEAR AI & ML

தமிழ் கவிதை
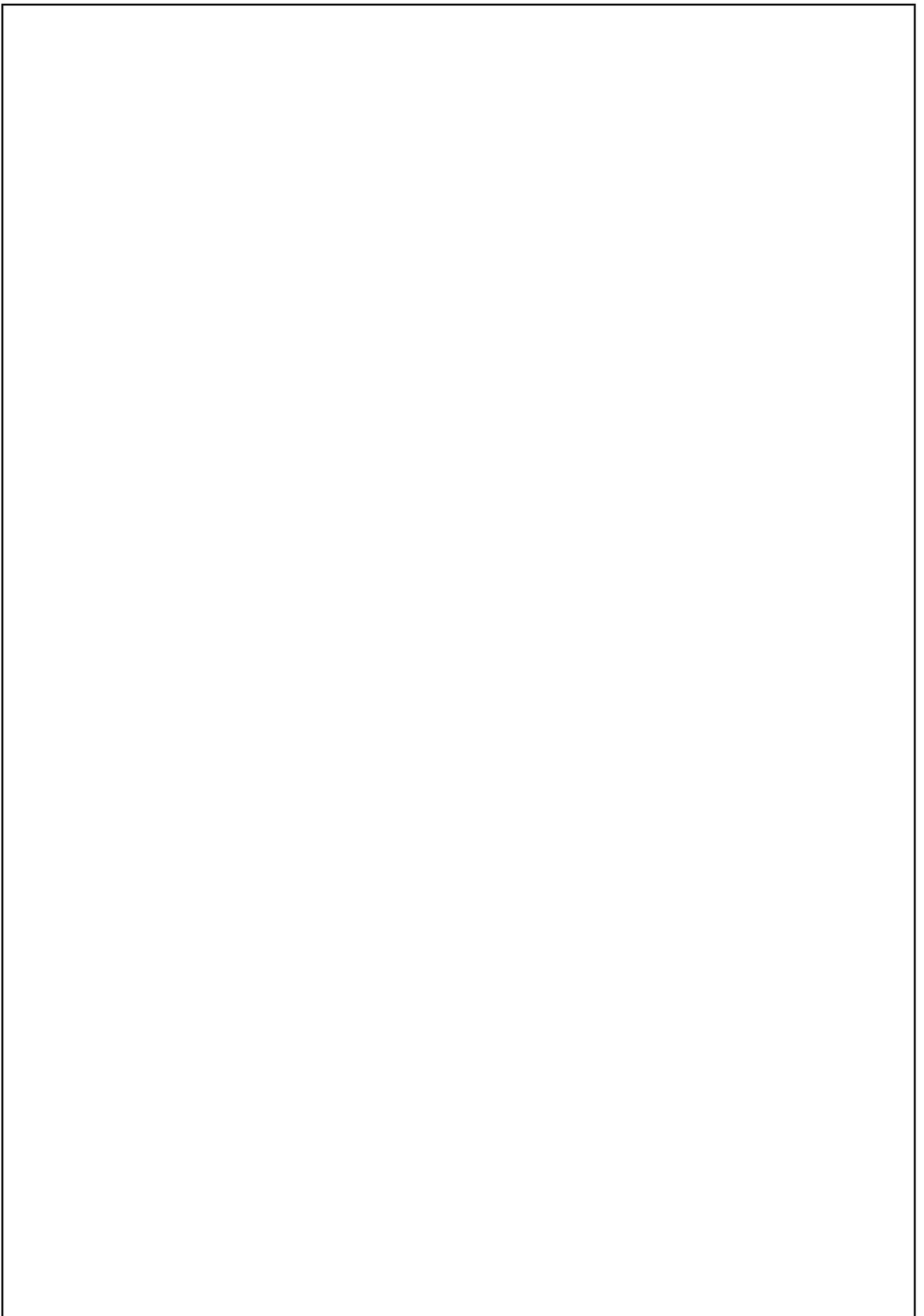
இயற்கை

இயற்கையே! நீயே நித்திய தர்மம்
எல்லாவற்றின் (மதங்களின்) அடிப்படை
உன்னை உணர்வதே ஆன்மிகம்

உன் அழகே தெய்வங்கள்
உன் சட்டங்களே வேதங்கள்
உன் அன்பளிப்பே வாழ்க்கை

உன்னை அறிவதே விஞ்ஞானம்
உன்னையொத்து வாழ்வதே புத்திசாலித்தனம்
உன்னை எதிர்ப்பது மடமை

Mr N ATHAVAN, II YEAR AERO

இயற்கையே உன் சீற்றங்கள் அடங்கட்டும்!
நீ ஆக்குவாய் காப்பாய் அழிப்பாய் அருள்தருவாய்!
அதனால், நீயே எல்லாவற்றிற்கும் அன்னை!
குற்றங்கள் பொறுத்து காப்பாயே!
உன்னைத் தவிர கதி வேறுயெதுவும் இல்லை !

Mr R MUKUNTHAN, III YEAR AUTO

விடிந்ததும் சிரிக்கிறேன்

விடிந்ததும் சிரிக்கிறேன்
அதுவரை அழுகிறேன்
ஆறாத துயரங்கள்
அணுவினில் கலந்திருக்கையில்
யாதும் அறியாமல் தவிக்கிறேன்
வினையூக்கியாய் இவ்விரவது
இருளினை ஊற்றுகையில்
கண்ணீரின் நிறங்கள் மாறுவதை
என் குறிப்பேட்டில் எழுதி கொள்கிறேன்

நேற்றுவரை தென்றல் என்றவை
இன்று முதல் பாதகமென்பதை
உணர்ந்ததால் சொல்கிறேன்

விடியும் வரை அழுகிறேன்

விழியினில் நிறைந்து
வெளிவருந் சிறு துளியின்
பாரமது ஒவ்வோர் நொடியிலும்
பெருகுவதை அறிகிறேன்

உறங்கும் விருட்சங்களுடன்
இருளின் மௌனங்களுடன்
கரைந்திட விரும்புகிறேன்
அதன் அலாதியான இன்பமே
இனி சூழ்வதை காண்கிறேன்

விடிந்ததும் சிரிக்கிறேன்,

இவ்வுலக நியதிக்குட்பட்டு
யாவையும் மறந்து....

Mr V PRASANTH, III YEAR BIO-MEDICAL

ENGLISH POEM
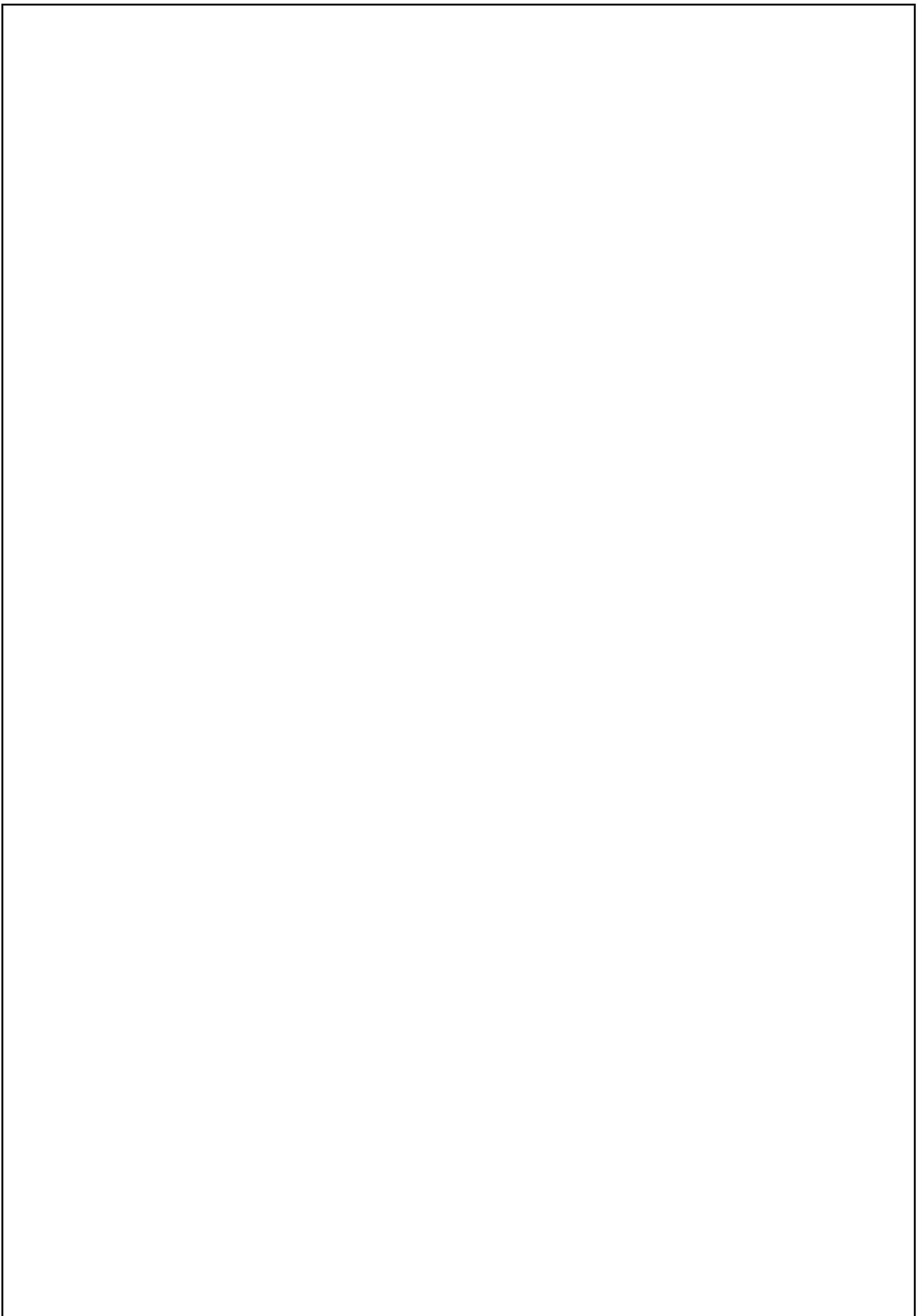
Two roads diverged in a yellow wood,
And sorry I could not travel both
And be one traveler, long I stood
And looked down one as far as I could
To where it bent in the undergrowth;

Then took the other, as just as fair,
And having perhaps the better claim,
Because it was grassy and wanted wear;
Though as for that the passing there
Had worn them really about the same,

And both that morning equally lay
In leaves no step had trodden black.
Oh, I kept the first for another day!
Yet knowing how way leads on to way,
I doubted if I should ever come back.

I shall be telling this with a sigh
Somewhere ages and ages hence:
Two roads diverged in a wood, and I—
I took the one less traveled by,
And that has made all the difference.

i carry your heart with me(i carry it in
my heart)i am never without it(anywhere
i go you go,my dear;and whatever is done
by only me is your doing,my darling)
i fear

no fate (for you are my fate,my sweet)i want

no world (for beautiful you are my world,my true)

and it's you are whatever a moon has always meant

and whatever a sun will always sing is you

here is the deepest secret nobody knows

(here is the root of the root and the bud of the bud

and the sky of the sky of a tree called life;which grows

higher than soul can hope or mind can hide)

and this is the wonder that's keeping the stars apart

i carry your heart (i carry it in my heart)

Mr M GOWTHAM, II YEAR AERO

How do you like to go up in a swing,

Up in the air so blue?

Oh, I do think it the pleasantest thing

Ever a child can do!

Up in the air and over the wall,

Till I can see so wide,

River and trees and cattle and all

Over the countryside—

Till I look down on the garden green,

Down on the roof so brown—

Up in the air I go flying again,

Up in the air and down!

Mr, DHILEEP K, II YEAR AUTO

Tyger Tyger, burning bright,

In the forests of the night;

What immortal hand or eye,

Could frame thy fearful symmetry?

In what distant deeps or skies

Burnt the fire of thine eyes?

On what wings dare he aspire?

What the hand, dare seize the fire?

And what shoulder, & what art,

Could twist the sinews of thy heart?

And when thy heart began to beat.

What dread hand? & what dread feet?

What the hammer? what the chain,

In what furnace was thy brain?

What the anvil? what dread grasp.

Dare its deadly terrors clasp?

When the stars threw down their spears

And water'd heaven with their tears:

Did he smile his work to see?

Did he who made the Lamb make thee?

Tyger Tyger burning bright,

In the forests of the night:

What immortal hand or eye,

Dare frame thy fearful symmetry?

Mr A ABISHEK III YEAR BME

If you can keep your head when all about you

Are losing theirs and blaming it on you,

If you can trust yourself when all men doubt you,

But make allowance for their doubting too;

If you can wait and not be tired by waiting,

Or being lied about, don't deal in lies,

Or being hated, don't give way to hating,

And yet don't look too good, nor talk too wise:

If you can dream—and not make dreams your master;

If you can think—and not make thoughts your aim;

If you can meet with Triumph and Disaster

And treat those two impostors just the same;

If you can bear to hear the truth you've spoken

Twisted by knaves to make a trap for fools,

Or watch the things you gave your life to, broken,

And stoop and build 'em up with worn-out tools:

If you can make one heap of all your winnings

And risk it on one turn of pitch-and-toss,

And lose, and start again at your beginnings

And never breathe a word about your loss;

If you can force your heart and nerve and sinew

To serve your turn long after they are gone,

And so hold on when there is nothing in you

Except the Will which says to them: 'Hold on!'

If you can talk with crowds and keep your virtue,

Or walk with Kings — nor lose the common touch,

If neither foes nor loving friends can hurt you,

If all men count with you, but none too much;

If you can fill the unforgiving minute

With sixty seconds' worth of distance run,

Yours is the Earth and everything that's in it,

And—which is more — you'll be a Man, my son!

Mr V BENJAMIN, III YEAR CIVIL

தமிழ் கட்டுரை

செயற்கை நுண்ணறிவு – நமது எதிர்காலம்

செயற்கை நுண்ணறிவு என்பது மனிதன் உருவாக்கிய அறிவியல் மேம்பாட்டின் முக்கிய அங்கமாக உள்ளது. Artificial Intelligence (AI) என்ற இத்துறை கணினி மற்றும் மென்பொருள்களால் மனித நுண்ணறிவைப் போன்ற செயல்களை செய்யும் திறனை பெறுகிறது. அதாவது, சிந்தனை, அறிவுத்திறன், செயல்திறன், முடிவெடுக்கும் திறன் போன்றவை இதில் அடங்கும்.

இன்று நாம் பல துறைகளில் செயற்கை நுண்ணறிவை பயன்படுத்துகிறோம். உதாரணமாக, தொலைபேசியில் உள்ள வோய்ஸ் அசிஸ்டெண்ட்கள், தானியங்கி வாகனங்கள், வங்கி செயல்பாடுகள், மருத்துவ கணிப்புகள், கல்வி செயலிகள்—all use AI. இவை அனைத்தும் மனித வாழ்க்கையை எளிதாக்கும் வகையில் வேலை செய்கின்றன.

தொழில்துறைகளில் AI மிக முக்கிய பங்கு வகிக்கிறது. உற்பத்தி துறையில் சுய இயக்க இயந்திரங்கள், வாடிக்கையாளர் சேவையில் Chatbots, பத்திரம் ஆய்வில் Natural Language Processing—all of these are real examples. AI மூலம் வேலை நேரமும் செலவும் குறைகின்றன.

கல்வித் துறையிலும் AI பெரிய மாற்றங்களை உருவாக்கி வருகிறது. மாணவர்களின் படிப்பு முறைகளை அறிந்து, தனிப்பட்ட வகையில் பாடங்களை வழங்கும் கல்வி பயன்பாடுகள் தற்போது வளர்ந்து வருகின்றன. AI-ஐ பயன்படுத்தி குறைவான நேரத்தில் அதிகமான தகவல்களை பயிற்சி செய்ய முடிகிறது.

மருத்துவ துறையில், நோய்களை முன்னதாக கண்டறிய AI உதவுகிறது. எடுத்துக்காட்டாக, X-ray, MRI, CT scan போன்றவற்றில் சிறு குறைகளை கண்டறிந்து, மருத்துவர்களுக்கு ஆலோசனை வழங்கும் செயலிகள் உருவாக்கப்பட்டுள்ளன. இது உயிர்கள் காக்கும் தொழில்நுட்பமாக மாறியுள்ளது.

செயற்கை நுண்ணறிவு (AI) நமது சமூகத்தின் பல்வேறு அம்சங்களை முற்றிலும் மாற்றி வடிவமைக்கும் ஆற்றலைக் கொண்ட ஒரு சிறப்பான தொழில்நுட்பமாகும். இது வேகமாக முன்னேறி வருவதால் நம்மைச்சுற்றி ஏற்படுத்தும் தாக்கங்களைப் பற்றி நாம் புரிந்து கொள்வது அவசியம். இந்த பதிவில் செயற்கை நுண்ணறிவின் எதிர்காலத்தை ஆராய்ந்து, அது எம்மாதிரியான மாற்றங்களை இவ்வுலகில் கொண்டுவரப் போகிறது என்பதைப் பற்றி பார்ப்போம்.

Machine Learning முன்னேற்றங்கள்: AI தொழில்நுட்பம் மெஷின்லர்னிங் என்னும் கணினி நிரலாக்க மொழியை அடிப்படையாகக் கொண்டு இயங்குவதாகும். இது எதிர்காலத்தில் பல்வேறு விதமான முன்னேற்றங்களைக் காணும் என எதிர்பார்க்கப்படுகிறது. இதன் மூலமாக அதிக அளவிலான தரவுகளை உருவாக்க முடியும் என்பதால், அதிநவீன வளர்ச்சியின் காரணமாக, மெஷின் லர்னிங் மேலும் சக்தி வாய்ந்ததாக மாறும். இதனால் பல மேம்பட்ட ஆட்டோமேஷன் மற்றும் இயந்திரங்கள் தானாக முடிவெடுக்கும் திறன்கள் வளர்ச்சிபெறும்.

ஆட்டோமேஷன் துறையின் வளர்ச்சி: இந்த தொழில்நுட்பத்தால் எதிர்காலத்தில் ஓட்டுனர் இன்றி இயங்கும் கார்கள், ரோபோக்கள் போன்றவை பிரபலமாகிவிடும். இந்த அமைப்புக்கு மனிதர்களின் பங்களிப்பு குறைவாகவே தேவை என்பதால், பல வேலைகள்

இல்லாமலேயே போய்விடும் வாய்ப்புள்ளது. குறிப்பாக போக்குவரத்து, உற்பத்தி, சுகாதாரம் மற்றும் பல துறைகளில் இதனால் பெரும் புரட்சி ஏற்படும் என சொல்லப்படுகிறது.

உரையாடும் AI: NPL எனப்படும் நேச்சுரல் லாங்குவேஜ் ப்ராசசிங் என்பது AI தொழில்நுட்பத்தின் அடுத்த நம்பிக்கையளிக்கும் முன்னேற்றமாகப் பார்க்கப்படுகிறது. இது இயந்திரங்கள் மனிதர்களின் மொழியைப் புரிந்துகொண்டு பதிலளிக்க உதவுவதாகும். உதாரணத்திற்கு விர்ச்சுவல் அசிஸ்டன்ட், ChatBot மற்றும் குரல் கட்டுப்பாட்டு சாதனங்களின் வளர்ச்சிக்கு இது வழிவகுக்கும்.

ஹெல்த்கேரில் AI: ஹெல்த்கேர் துறையில் செயற்கை நுண்ணறிவின் தாக்கம் இப்போது தெரியத் தொடங்கியுள்ள நிலையில், இது எதிர்காலத்தில் தொடர்ந்து வளரும் என எதிர்பார்க்கலாம். ஏஐ மூலமாக இயங்கும் அமைப்புகள், மருத்துவத் தரவுகளை பகுப்பாய்வு செய்து, சிகிச்சைத் திட்டங்களை வகுப்பதற்கு உதவும். இது ஆரம்பகால நோயைக் கண்டறிவது முதல் புதிய மருந்துகளை கண்டுபிடிப்பது வரை சுகாதாரத் துறையில் பெரும் புரட்சியை ஏற்படுத்தும்.

மாற்றம் பெறும் வேலைமுறை: எதிர்காலத்தில் பல துறைகளில் ஏஐ பங்களிக்கும் என்பதால், வேலை முறைகளில் பல மாற்றங்களைக் கொண்டு வரும் என எதிர்பார்க்கப்படுகிறது. இதன் மூலமாக சில வேலைகள் ஆட்டோமேஷன் செய்யப்படும் நேரத்தில், பல புதிய வேலை வாய்ப்புகளும் உருவாகும். குறிப்பாக படைப்பாற்றல் துறையில் இதனால் பெரும் மாற்றம் ஏற்படும் எனக் கணிக்கப்பட்டுள்ளது.

AI மற்றும் கல்வி: இதனால் கல்வித்துறையில் அறிவார்ந்த பயிற்சி அமைப்புகள் செயல்படுத்தப்பட்டு, பல மாற்றங்கள் ஏற்படலாம். மாணவர்களுக்கு கற்பிக்க விர்ச்சுவல் ரியாலிட்டி சிமுலேஷன், செயற்கை நுண்ணறிவு மூலமாக இயங்கும் கல்விக் கருவிகள் ஆகியவை கல்விப் பயணத்தை மேம்படுத்தும். மேலும் மாணவர்கள் கற்றலை மிகவும் ஈடுபாட்டுடன் அணுகக்கூடியதாக மாற்றியமைக்கும்.

இப்படி செயற்கை நுண்ணறிவின் எதிர்காலம் பல்வேறு விஷயங்களில் பெரும் புரட்சியை ஏற்படுத்தும் மகத்தான ஆற்றலைக் கொண்டுள்ளது. எனவே இதைக் குறையாகப் பார்க்காமல், எதிர்காலத்தில் மனித குலத்திற்கு பெரும் நன்மை புரியப் போகிறது என்பதை உணர்ந்து, இப்போதிலிருந்தே கொஞ்சம் கொஞ்சமாக இதற்கு நம்மை தயார் செய்துகொள்ள வேண்டியது அவசியம்.

ஆனால், AI-இன் வளர்ச்சி பயத்தை எழுப்பும் வகையிலும் உள்ளது. குறிப்பாக, பல வேலைவாய்ப்புகள் குறைவடைவதற்கான வாய்ப்பு உள்ளது. மனிதர்களை மாற்றும் ரோபோட்டுகள் மற்றும் மெஷின்கள் கூட பரவலாக இருக்கின்றன. இதனால் வேலைவாய்ப்பு மற்றும் மனிதப் பங்கு குறைகிறது.

இன்னும் ஒரு சவாலாக எதிகா (Ethics) மற்றும் பாதுகாப்பு பிரச்சனைகள் கூறலாம். AI-ஐ தவறாக பயன்படுத்தும் வாய்ப்புகள் இருப்பதால், அதற்கான சட்டம் மற்றும் கட்டுப்பாடுகள் அமைய வேண்டும். செயற்கை நுண்ணறிவு மனிதருக்கு உதவியாக இருக்க வேண்டுமே தவிர, அதை கட்டுப்படுத்தும் வகையில் இருக்கக் கூடாது.

முடிவாக, செயற்கை நுண்ணறிவு நம் எதிர்காலத்தின் முக்கிய கருவியாக இருக்கிறது. அதை நாம் அறிவுடன், நன்மைக்கு பயன்படுத்தினால், இது மனித வாழ்க்கையை மேம்படுத்தும். எனவே, AI

என்பது நம்முடைய எதிர்கால வளர்ச்சிக்கு ஒர் அடையாளமாகவே அமையும்.

MR G BALA
II YEAR AI & ML

மின்னணு மற்றும் இயந்திர ஒருங்கிணைப்பு

அறிமுகம்:

மின்னணு மற்றும் இயந்திர ஒருங்கிணைப்பு என்பது இன்று தொழில்நுட்ப வளர்ச்சியின் மையமாக விளங்கும் முக்கிய துறையாகும். இத்துறையால் உருவாகும் சாதனங்கள் மற்றும் முறைகள் மனித வாழ்க்கையை எளிதாக்கி, தொழில்நுட்ப திறன்களையும் வேலை திறன்களையும் பெரிதும் மேம்படுத்துகின்றன. இந்த ஒருங்கிணைப்பு 'மெக்காட்ரானிக்ஸ் (Mechatronics)' எனப்படும் புதிய அறிவியல் துறைக்கு அடித்தளம் அமைத்துள்ளது.

1. ஒருங்கிணைப்பு என்ன?

மின்னணு மற்றும் இயந்திர கூறுகள் ஒருங்கிணைக்கப்பட்டு செயல்படுவதே இந்த துறையின் அடிப்படை. இதில் மைக்ரோகன்ட்ரோலர்கள், சென்சார்கள், இயக்கிகள், மற்றும் மெக்கானிக்கல் அமைப்புகள் ஒரே பிளாட்ஃபார்மில் இணைந்து செயல்படுகின்றன. இதில் கணினி கட்டுப்பாடும் (control system) முக்கிய பங்கு வகிக்கிறது.

உதாரணமாக, ஒரு சுய இயக்கும் வாகனத்தில் காட்சி, தானாக சுழலும் டயர்கள், தடையினை உணரும் சென்சார்கள் மற்றும் செயற்கை நுண்ணறிவுடன் இயங்கும் இயக்க அமைப்புகள்—all these work together.

2. தொழில்துறை பயன்பாடுகள்

இந்த ஒருங்கிணைப்பின் மூலம் பல தொழில்துறைகள் மேம்பாட்டைப் பெற்றுள்ளன:

தானியங்கி உற்பத்தி (Automation):

இயந்திரங்களை தானாக இயக்கி, ஒரே நேரத்தில் பல செயல்களைச் செய்ய உதவுகிறது.

ரோபோட்டிக்ஸ்:

குறிப்பிட்ட வேலைகளை துல்லியமாக செய்யக்கூடிய ரோபோட்டுகள் மின்னணு கட்டுப்பாடுகளால் இயக்கப்படுகின்றன.

தானியக்க வாகனங்கள் (Autonomous Vehicles):

மின்னணு மற்றும் மெக்கானிக்கல் கூறுகளின் ஒருங்கிணைப்பால் சுய இயக்க வாகனங்கள் சாத்தியமாகின்றன.

3. மருத்துவ துறையில் பங்கு

மருத்துவ ரோபோட்டிக்ஸ், கண்காணிப்பு கருவிகள், செயற்கை உடல்கூறுகள் மனித உருவ அமைப்பைப் போன்ற இயக்கங்கள் செயற்கை கைகளில் உருவாகின்றன. துல்லிய அறுவை சிகிச்சைகள் பல மருத்துவ மையங்களில் வழக்கம்.

4. வேளாண்மை, பாதுகாப்பு மற்றும் கல்வி துறைகள்

வேளாண்மை: பசுமை விவசாயம், நிலவீட்ட சேமிப்பு, மண்ணில் ஈரப்பதம் அளவை சென்சார் மூலம் கணிக்கலாம்.

பாதுகாப்பு: ஹூஇமனாய்ட் ரோபோட்டுகள், சிசிடிவி தானியங்கி கண்காணிப்பு அமைப்புகள்.

கல்வி: CNC சிமுலேட்டர்கள், AutoLab, IoT-based experiments ஆகியவை மாணவர்களுக்கு தொழில்நுட்பத் திறனை வழங்குகின்றன.

5. எதிர்காலம் மற்றும் சவால்கள்

மின்னணு மற்றும் இயந்திர ஒருங்கிணைப்பு தொடர்ந்து விரிவடையும் துறையாக இருக்கிறது. ஆனால், இதற்கான சவால்கள்:

அதிக செலவு

மேம்பட்ட அறிவு தேவை

தொழிலாளர்களுக்கான மறுசுழற்சி பயிற்சி தேவை

இவை அனைத்தையும் அரசாங்கம் மற்றும் தொழிற்சாலைகள் இணைந்து மேம்படுத்தினால், இது தொழில்துறையில் பெரிய புரட்சியாக மாறும்.

முடிவுரை:

மின்னணு மற்றும் இயந்திர ஒருங்கிணைப்பு என்பது தொழில்நுட்ப வளர்ச்சியின் முன்னோடி. இது மனித உழைப்பை சிக்கனமாக மாற்றுவதோடு, உயர் தரமான தொழில் முடிவுகளையும் தருகிறது. இதனை நாமும் பயன்படுத்தி, தொழில்நுட்ப உலகத்தில் முன்னேற வேண்டும். அவசியம்.

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Mr R ADHITYA
III YEAR MECHATRONICS ENGG.,

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பசுமை எரிபொருள் மற்றும் அதன் முக்கியத்துவம்

இன்றைய உலகில் எரிபொருள் தேவைகள் நாளுக்கு நாள் அதிகரித்து வருகின்றன. இதனால் பாரம்பரிய எரிபொருட்கள் (பெட்ரோல், டீசல் போன்றவை) விரைவாக குறைந்து வருகின்றன. இவை அதிகளவிலான மாசுபாட்டை உருவாக்குவதால் சுற்றுச்சூழலுக்கு மிகுந்த தீங்கு விளைவிக்கின்றன. இதற்குத் தீர்வாக பசுமை எரிபொருட்கள் அறிமுகப்படுத்தப்பட்டு வருகின்றன.

பசுமை எரிபொருட்கள் என்பது இயற்கை மூலப்பொருட்களிலிருந்து தயாரிக்கப்படும், சுற்றுச்சூழலுக்கு இடர் இல்லாத எரிபொருட்களாகும். உதாரணமாக, பயோடீசல், எத்தனால், ஹைட்ரஜன், மிதேன் ஆகியவை குறிப்பிடத்தக்க பசுமை எரிபொருட்கள் ஆகும்.

பசுமை எரிபொருட்களின் முக்கியத்துவம் பலரீதியாக உள்ளது. முதலாவதாக, இவை புதுப்பிக்கத்தக்க மூலப்பொருட்களால் தயாரிக்கப்படுகின்றன, எனவே இனி எரிபொருள் பற்றாக்குறை ஏற்பட வாய்ப்பில்லை. இரண்டாவதாக, இவை எரியும் போது வெளியேறும் கார்பன் டைஆக்சைடு மற்றும் பிற வாயுக்களின் அளவு குறைவாக இருக்கும்.

மூன்றாவதாக, பசுமை எரிபொருட்கள் ஊக்குவிக்கப்படுவதன் மூலம் விவசாயத்துக்கு ஆதரவாக செயல்படும். எ.கா., மக்காச் சோளம், ஊஞ்சல் எண்ணெய் போன்றவற்றிலிருந்து எரிபொருட்கள் தயாரிக்கப்படும். இது விவசாய வருமானத்தையும் அதிகரிக்க உதவுகிறது.

பசுமை எரிபொருட்கள் மக்களுக்கு நோய்களின் பரவலைக் குறைக்கும். காரணம், தூய்மையான எரிபொருள் எரிவதால் காற்று மாசுபாடு குறைகிறது. இதன் மூலம் சுவாச நோய்கள், வாந்தி, தலைவலி போன்ற பிரச்சனைகள் குறையும்.

பசுமை எரிபொருட்களின் வகைகள்:

உயிரி எரிபொருட்கள்:

உயிரி எரிபொருட்கள், தாவரங்கள் மற்றும் விலங்குகளின் கழிவுகளைப் பயன்படுத்தி தயாரிக்கப்படுகின்றன. இவை எரிவாயு, திரவ எரிபொருள் மற்றும் திட எரிபொருள் என பல வடிவங்களில் கிடைக்கின்றன.

ஹைட்ரஜன்:

ஹைட்ரஜன் ஒரு தூய்மையான எரிபொருள் ஆகும், இதை தண்ணீரில் இருந்து பிரித்தெடுக்கலாம். இது மின்சார உற்பத்தி மற்றும் வாகனங்களுக்கு எரிபொருளாகப் பயன்படுத்தப்படுகிறது.

சூரிய எரிசக்தி:

சூரிய ஒளியை மின்சாரமாக மாற்றும் தொழில்நுட்பம் இதுவாகும்.

காற்று எரிசக்தி:

காற்று விசையாழிகள் மூலம் காற்றாலைகளிலிருந்து மின்சாரம் தயாரிக்கப்படுகிறது.

புவிவெப்ப எரிசக்தி:

புவி வெப்பத்தை பயன்படுத்தி மின்சாரம் மற்றும் வெப்பத்தை உற்பத்தி செய்யப்படுகிறது.

சுருக்கமாக, பசுமை எரிபொருள் சுற்றுச்சூழலை பாதுகாக்கவும், நிலைத்தன்மையை மேம்படுத்தவும், பொருளாதார வளர்ச்சியை ஊக்குவிக்கவும் மற்றும் மக்களின் ஆரோக்கியத்தை மேம்படுத்தவும் ஒரு முக்கிய கருவியாகும்.

இன்னும் சில நாட்களில், பல நாடுகள் பசுமை எரிபொருள் மீது அதிக கவனம் செலுத்துகின்றன. இந்தியா போன்ற வளர்ச்சி பெறும் நாடுகளும் இதை ஊக்குவிக்க முயற்சிக்கின்றன. இந்திய அரசும் எத்தனால்-மிக்ஸ் பெட்ரோல் மற்றும் பயோடீசல் இயக்கும் வாகனங்களை ஊக்குவிக்க திட்டங்களை அறிவித்துள்ளது.
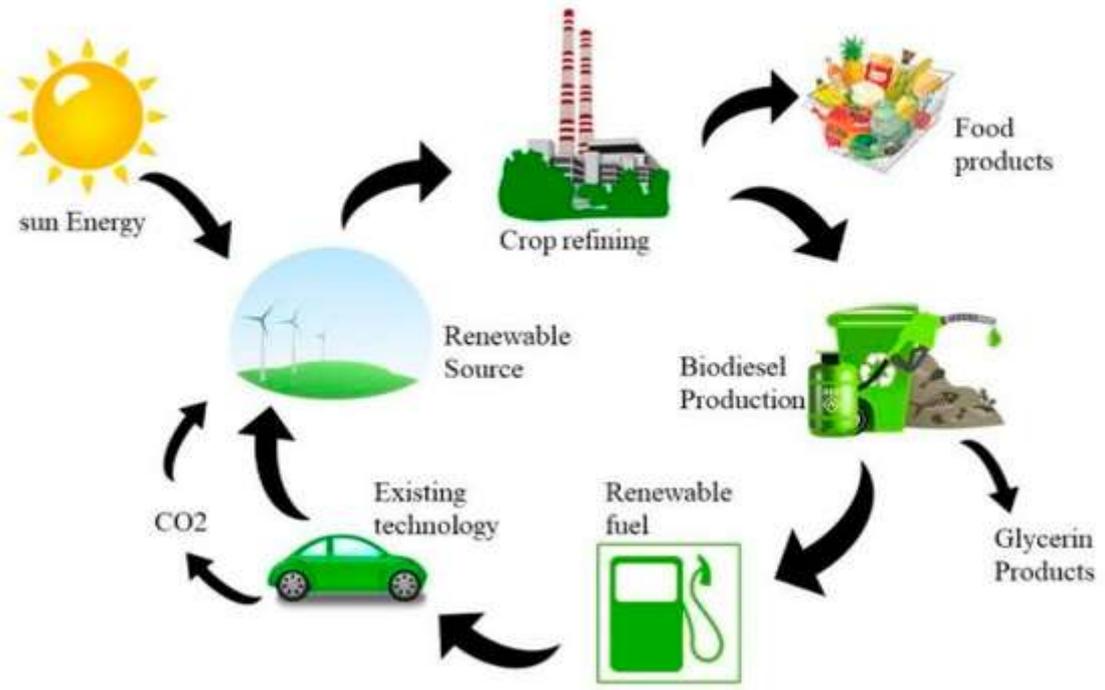
முடிவுரையாக, பசுமை எரிபொருட்கள் என்பது எதிர்கால வாகன உலகத்தின் நம்பிக்கையான மாற்று வழியாக உள்ளது. சுற்றுச்சூழலை பாதுகாக்கவும், மனித சமூகத்தின் நலனை மேம்படுத்தவும் பசுமை எரிபொருட்கள் முக்கிய பங்கு வகிக்கின்றன. எனவே இதனை நாம் அனைவரும் ஒப்புக்கொண்டு, நம் வாழ்க்கையில் பயன்படுத்த துவங்கவேண்டும்.

ANEESH AKTHAR
III YEAR AUTOMOBILE ENGINEERING

பருவநிலை மாற்றத்தில் வேதியியல் தொழில்களின் தாக்கம்

இன்றைய உலகம் பருவநிலை மாற்றத்தின் தாக்கங்களை மிகக் கடுமையாக எதிர்கொண்டு வருகிறது. அதிக வெப்பம், வறட்சிகள், கடும் மழை, பனிச்சரிவுகள் மற்றும் கடல்மட்ட உயர்வுகள் போன்ற பல பாதிப்புகள் மனித வாழ்க்கையை பெரிதும் பாதித்து வருகின்றன. இந்த பருவநிலை மாற்றத்திற்கு காரணமாகக் காணப்படுவது மிகவும் முக்கியமானது - மனிதன் உருவாக்கிய தொழில்நுட்பங்கள் மற்றும் தொழில்துறைகள்.

இந்த தொழில்துறைகளில் முக்கியமான பங்கு வகிப்பது வேதியியல் தொழில்கள் ஆகும். உதாரணமாக, உரவியல் தொழில்கள், பாலிமர் உற்பத்தி தொழில்கள், இரசாயன சுத்திகரிப்பு நிலையங்கள், மருந்து மற்றும் உலோக உற்பத்தி தொழில்கள் ஆகியவை பெருமளவில் கார்பன் டைஆக்சைடு, மீதேன், நைட்ரஸ் ஆக்சைடு போன்ற பசுமைக் கொத்துகளாகும் வாயுக்களை வெளியிடுகின்றன.

இந்த வாயுக்கள் காற்றில் சிக்கி, வெப்பத்தை பூமிக்கு தேக்குவதன் மூலம் 'கிரீன்ஹவுஸ் விளைவு' ஏற்படுகிறது. இதுவே உலக வெப்பமயமாதலுக்கு வழிவகுக்கிறது. வேதியியல் தொழில்களில் பயன்படுத்தப்படும் மூலப்பொருட்கள் மற்றும் சத்தங்கள் அதிகளவில் மாசுபாட்டை ஏற்படுத்தும் தன்மை கொண்டவை. இதனால், நிலத்தடி நீர், காற்று, மற்றும் மண்ணும் பாதிக்கப்படுகின்றன.

இந்தப் பிரச்சனையை தீர்க்கும் வழிகள் பல உள்ளன. முதலில், வேதியியல் தொழில்களில் சுத்திகரிப்பு சாதனங்கள் மற்றும் நவீன தொழில்நுட்பங்களை பயன்படுத்தி வெளியேறும் வாயுக்களின் அளவை குறைக்கலாம். அதோடு, பசுமை வேதியியல் முறைகளை (Green Chemistry) கடைப்பிடித்து, சுற்றுச்சூழல் பாதிப்பு குறைவான இயற்கை மூலப்பொருட்கள் மற்றும் நுண்ணறிவு தொழில்நுட்பங்களை கொண்டு செயல்பட முடியும்.

மேலும், தொழிற்சாலைகளில் எரிபொருள் நுண்ணறிவாக மாற்றம் செய்யும் உபகரணங்கள், பசுமை எரிபொருள் பயன்பாடு, கழிவுகளை மீள்சுழற்சி செய்யும் முறைகள் ஆகியவையும் அமல்படுத்தப்பட வேண்டும். அரசாங்கங்கள் கண்டிப்பான சுற்றுச்சூழல் விதிகளை வகுத்து, அவற்றை கட்டாயமாக்கவேண்டும்.

பருவநிலை மாற்றத்தைக் கட்டுப்படுத்த வேதியியல் பொறியாளர்கள் முக்கிய பங்கு வகிக்கின்றனர். அவர்கள் உருவாக்கும் புதிய தொழில்நுட்பங்கள், சுத்தமான உற்பத்தி முறைகள் மற்றும் பசுமை வேதியியல் திட்டங்கள் எல்லாம் எதிர்காலத்தை பாதுகாக்கும் உந்துசக்தியாக இருக்கும்.

முடிவுரை: பருவநிலை மாற்றம் என்பது மனிதனின் செயல் விளைவாக உருவான பெரும் பிரச்சனை. அதைச் சரிசெய்யவேண்டும் என்றால், வேதியியல் தொழில்கள் தங்கள் செயல்பாடுகளில் பசுமை மாற்றங்களை கொண்டு வர வேண்டும். சுற்றுச்சூழலுக்கு தோழமையான தொழில்நுட்பங்களை பயன்படுத்தி, மனிதன் மற்றும் இயற்கைக்கு இடையிலான சமநிலையை நிலைநாட்டவேண்டும்.

MR A GOWTHAM
II YEAR CHEMICAL ENGINEERING

ENGLISH ESSAY
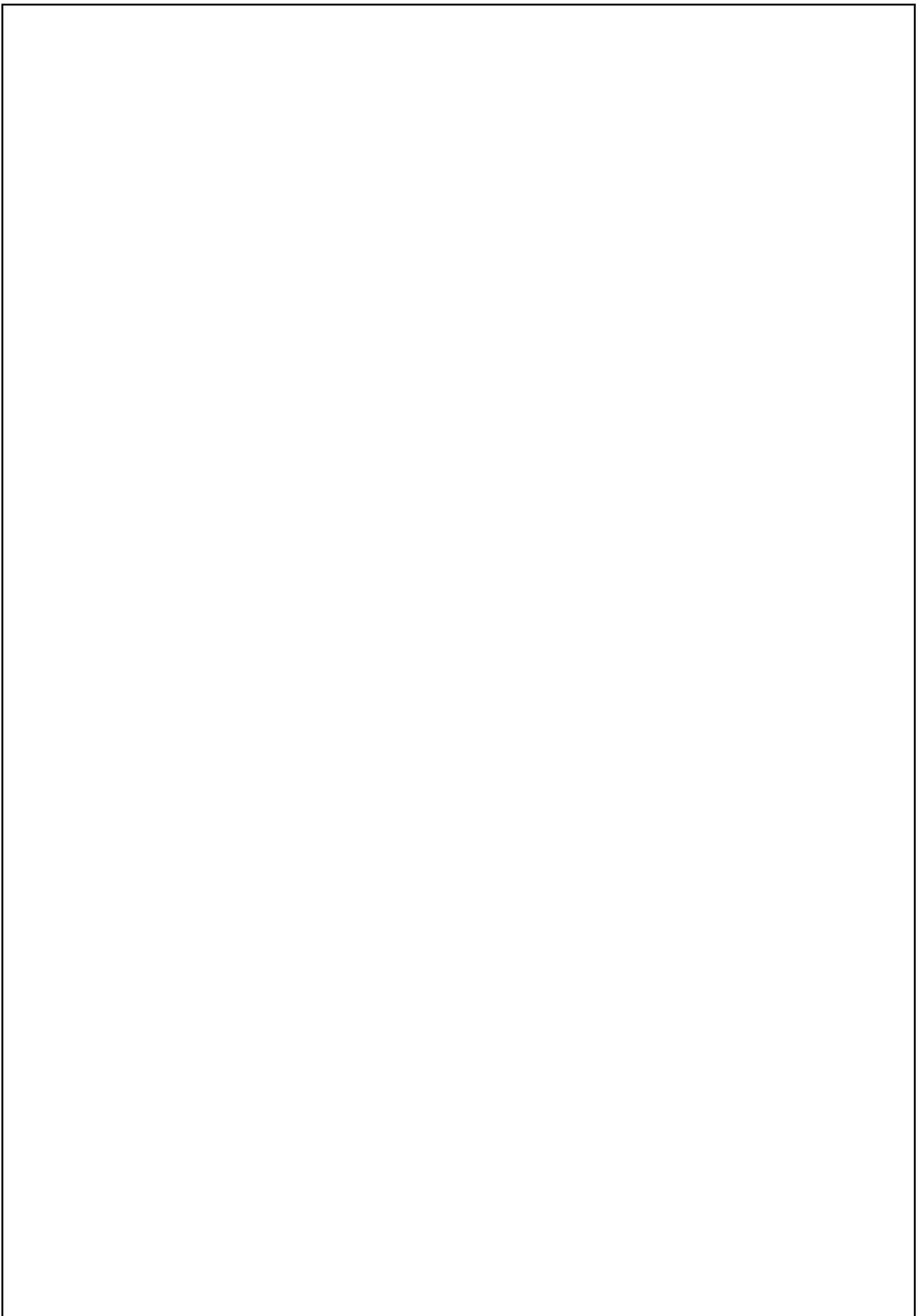
CYBERSECURITY: SAFEGUARDING THE DIGITAL WORLD

Ms. D Kavya, IV YEAR CSE

In today's hyper-connected world, where digital infrastructure powers everything from personal communication and financial systems to critical infrastructure and national security, cybersecurity has become a foundational pillar of modern society. With the rise of cloud computing, mobile technologies, IoT, and artificial intelligence, digital systems are more complex and vulnerable than ever before. Cybersecurity aims to protect systems, networks, and data from cyber threats, ensuring confidentiality, integrity, and availability.

Cybersecurity

Cybersecurity refers to the practice of protecting computers, servers, mobile devices, networks, and data from malicious attacks, unauthorized access, and damage. It encompasses a wide range of technologies, processes, and practices designed to defend digital assets and users from evolving threats.

Core Goals (CIA Triad):

✓ Confidentiality: Ensuring that sensitive data is accessed only by authorized individuals.

- ✓ Integrity: Ensuring that information remains accurate and unaltered.
- ✓ Availability: Ensuring that systems and data are accessible when needed.

2. Types of Cyber Threats

a) Malware

Short for "malicious software," malware includes viruses, worms, ransomware, spyware, and Trojans. It can damage systems, steal information, or give attackers control over a system.

b) Phishing

A method of tricking users into revealing sensitive data like passwords and credit card numbers, often through fake emails or websites.

c) Ransomware

A form of malware that encrypts a user's data and demands payment to restore access. High-profile ransomware attacks have disrupted hospitals, municipalities, and global corporations.

d) Denial-of-Service (DoS/DDoS) Attacks

Overwhelm systems or networks with traffic, rendering services unavailable to legitimate users.

e) Man-in-the-Middle (MitM) Attacks

Interception of communication between two parties to eavesdrop or alter the data being transferred.

f) Zero-Day Exploits

Attacks that exploit previously unknown vulnerabilities in software before a fix is available.

3. Key Cybersecurity Domains

a) Network Security

Protects internal networks from intrusions by securing routers, firewalls, intrusion detection systems (IDS), and network segmentation.

b) Application Security

Ensures that software is free from vulnerabilities through secure coding practices, application testing, and regular patching.

c) Cloud Security

Secures data and applications hosted in cloud environments, focusing on access control, encryption, and shared responsibility models.

d) Endpoint Security

Protects end-user devices such as computers, smartphones, and tablets from threats through antivirus software, firewalls, and device management systems.

e) Identity and Access Management (IAM)

Ensures that the right individuals access the right resources at the right times, using multi-factor authentication (MFA), biometrics, and role-based access control.

f) Data Security

Focuses on protecting data at rest, in transit, and in use through encryption, tokenization, and secure storage.

g) Operational Security

Covers the policies and procedures that manage and protect data assets, including incident response plans and risk management.

4. Emerging Technologies and Trends in Cybersecurity

a) Artificial Intelligence and Machine Learning

AI helps in threat detection, behavior analysis, and automated response to anomalies. It enables security systems to learn from past incidents and predict future threats.

b) Zero Trust Architecture

A security model that assumes no user or system is trustworthy by default. It verifies every access request regardless of source location.

c) Cybersecurity Mesh

A decentralized approach where security perimeters are defined around individuals and devices rather than the network as a whole.

d) Blockchain Security

Used for secure data storage and authentication due to its tamper-proof and decentralized nature.

e) Quantum Cryptography

In development, this promises to create theoretically unbreakable encryption using quantum mechanics.

5. Real-World Cybersecurity Incidents

WannaCry (2017): A ransomware attack that affected 200,000+ computers in 150 countries, including NHS hospitals in the UK.

SolarWinds Attack (2020): A sophisticated supply chain attack impacting U.S. government agencies and private companies.

Equifax Data Breach (2017): Exposed sensitive personal data of 147 million Americans due to a known unpatched vulnerability.

6. Best Practices for Cybersecurity

- ✓ Regular Software Updates and Patching
- ✓ Strong Password Policies and Use of MFA
- ✓ Security Awareness Training
- ✓ Data Backups and Recovery Plans
- ✓ Use of Antivirus and Anti-Malware Solutions
- ✓ Encrypted Communication (HTTPS, VPNs)
- ✓ Incident Response and Business Continuity Plans

7. Cybersecurity in Critical Sectors

- ✓ Finance: Protection against fraud, identity theft, and data breaches.
- ✓ Healthcare: Safeguarding patient data (HIPAA compliance).
- ✓ Energy and Utilities: Defense against cyber-attacks targeting infrastructure (e.g., power grids).

- ✓ Government: Protection of national security and classified information.
- ✓ Education: Defense against ransomware and data leaks involving students and staff.

8. Challenges in Cybersecurity

☐ Sophistication of Attacks: Attackers use AI and automation to stay ahead.

☐ Shortage of Cybersecurity Professionals: An estimated 3.5 million jobs globally remain unfilled.

☐ Increased Attack Surface: Due to remote work, mobile devices, and IoT.

☐ Complex Regulatory Environment: GDPR, CCPA, HIPAA, and others require strict compliance.

☐ Insider Threats: Employees can unintentionally or maliciously cause breaches.

9. The Future of Cybersecurity

The future will see more intelligent, adaptive, and autonomous security systems. Key developments include:

☐ Autonomous Security Operations Centers (SOC)

☐ Proactive Threat Hunting

☐ Cross-sector Cyber Defense Alliances

☐ Digital Identity as a Service (DIaaS)

☐ Global Cybersecurity Regulations and Frameworks

Conclusion

Cybersecurity is no longer an optional layer of IT but a core part of every organization's risk management strategy. In an increasingly digital world, where cyber threats are more frequent, sophisticated, and damaging, investing in cybersecurity is essential for protecting not just data and systems, but public trust and organizational reputation. As technology evolves, so must our commitment to continuous improvement in cybersecurity defenses, policies, and education.

AI IN URBAN DEVELOPMENT AND INFRASTRUCTURE

Mr D Dharun Prabhu, II Year AIML

Transforming the Future of Cities

Artificial Intelligence (AI) is revolutionizing urban development and infrastructure by enabling smarter, data-driven decisions that improve city efficiency, sustainability, and quality of life. In urban planning, AI analyzes satellite imagery, census data, and traffic patterns to forecast population growth, optimize land use, and simulate infrastructure needs. AI-driven smart traffic systems, using real-time data from IoT sensors, GPS, and CCTV feeds, can reduce congestion by up to 25% and cut travel time by 20% through adaptive signal control and route optimization. In transportation, AI supports autonomous vehicles, predictive public transit schedules, and mobility-as-a-service platforms, enhancing accessibility and reducing emissions. Infrastructure maintenance benefits from AI-powered drones and sensor networks that monitor structural health and predict failures—helping cities avoid costly breakdowns and extending asset life. Smart grids, guided by AI algorithms, improve energy efficiency by dynamically adjusting supply based on consumption patterns, while AI-driven building management systems can reduce energy usage in commercial buildings by 30%. Waste management is optimized through AI-enabled route planning and automated sorting, increasing recycling rates and lowering fuel consumption. Environmental monitoring systems leverage machine learning to detect air and water pollution in real time, enabling faster governmental response. In public safety, AI aids in crime prediction, emergency dispatch, and disaster response, using pattern recognition to allocate resources more effectively. However, the implementation of AI in urban contexts raises challenges such as algorithmic bias, cybersecurity threats, and privacy concerns, demanding ethical AI design and inclusive policymaking. Overall, AI offers transformative potential in

urban development, enabling resilient, adaptive, and citizen-centric smart cities.

Artificial Intelligence (AI) is rapidly becoming a cornerstone in the evolution of urban development and infrastructure. With the exponential growth of urban populations and the increasing complexity of city systems, governments and urban planners are turning to AI-powered solutions to create smarter, more sustainable, and efficient urban environments.

AI for Smart City Planning

AI enhances urban planning by analyzing vast amounts of data to model city growth, optimize land use, and forecast infrastructure demands. Geographic Information Systems (GIS) integrated with AI can simulate population density, traffic flow, and environmental impacts, enabling data-driven decisions. This predictive capability allows cities to plan infrastructure projects more effectively and avoid overbuilding or underutilization.

Traffic and Transportation Management

AI has revolutionized transportation systems through intelligent traffic control, route optimization, and predictive maintenance. AI algorithms analyze real-time data from traffic cameras, sensors, and GPS devices to manage congestion, reduce travel times, and improve public transport reliability. Autonomous vehicles and AI-powered ride-sharing services are also reshaping urban mobility.

Infrastructure Monitoring and Maintenance

Maintaining infrastructure is vital for safety and functionality. AI-powered drones and sensors can monitor bridges, roads, pipelines, and buildings in real time, detecting structural defects, corrosion, or other

anomalies early. Machine learning models can predict when infrastructure components are likely to fail, enabling proactive maintenance and reducing costs.

Energy Efficiency and Smart Grids

AI facilitates the optimization of urban energy systems through smart grids that adjust energy distribution based on demand. AI also supports the integration of renewable energy sources by forecasting energy needs and managing storage. In buildings, AI systems regulate lighting, heating, and cooling to minimize energy use and reduce carbon footprints.

Waste Management and Environmental Monitoring

AI applications in waste management include route optimization for garbage collection trucks and automated waste sorting in recycling facilities. Environmental AI systems monitor air and water quality, noise pollution, and other environmental factors, alerting authorities to potential hazards and aiding in long-term sustainability planning.

Public Safety and Emergency Response

Urban safety is improved with AI-driven surveillance systems that can detect unusual activities or crowd movements in real time. AI is also employed in disaster management, analyzing historical data to predict natural disasters and coordinating emergency responses using drones and robotics.

Challenges and Ethical Considerations

Despite its benefits, integrating AI into urban infrastructure poses challenges. These include data privacy concerns, cybersecurity risks, the digital divide, and the potential for algorithmic bias. Transparent governance and inclusive AI design are essential to ensure equitable benefits for all urban residents.

Conclusion

AI is set to redefine urban development and infrastructure, offering tools to create safer, smarter, and more sustainable cities. By harnessing the power of data and machine intelligence, urban planners and policymakers can address the complex challenges of urbanization, ensuring a high quality of life for current and future generations.

SMART EV: AN IOT-BASED ELECTRIC VEHICLE WITH INTELLIGENT CHARGING AND PREDICTIVE MAINTENANCE

Mr S Vignesh Kumar, IV Year Automobile Engg.,

The global shift toward sustainable mobility has accelerated the adoption of Electric Vehicles (EVs). While EVs themselves offer a cleaner alternative to fossil fuel-powered vehicles, integrating Internet of Things (IoT) technology is transforming them into Smart EVs—vehicles that are not only electric but also intelligent, connected, and autonomous. Two key aspects of this transformation are intelligent charging and predictive maintenance, both enabled by real-time data, cloud computing, and edge analytics.

Overview of IoT in Electric Vehicles

IoT in electric vehicles involves embedding sensors, processors, and connectivity modules into the vehicle's subsystems. These modules collect and transmit data to cloud platforms or mobile applications. With this, real-time monitoring, control, diagnostics, and automation become possible. Key data points include battery temperature, state of charge (SOC), motor performance, braking system behavior, tire pressure, and vehicle location.

Intelligent Charging Systems

Smart charging leverages IoT, AI, and cloud infrastructure to optimize EV charging both at home and in public stations. Features include:

- Dynamic Charging Scheduling: Based on electricity tariffs, grid load, and user preferences, the vehicle schedules charging during off-peak hours to minimize cost and grid strain.
- Real-time Battery Monitoring: IoT sensors track SOC, depth of discharge (DOD), and battery health to prevent overcharging and overheating, increasing battery life.

- Remote Control and Alerts: Through a mobile app, users can remotely initiate or stop charging, receive alerts about charging status, and locate the nearest available station.
- V2G (Vehicle-to-Grid) Integration: Smart EVs can feed electricity back to the grid during peak demand. IoT systems manage bidirectional energy flow efficiently and securely.
- Solar and Renewable Energy Optimization: For homes with solar panels, smart charging can align EV charging with peak solar generation, reducing dependence on grid energy.
-

Predictive Maintenance

Predictive maintenance uses machine learning algorithms to analyze sensor data from vehicle components and forecast potential failures before they happen. Key functionalities include:

- Condition-Based Monitoring: Instead of relying on fixed service intervals, IoT-enabled EVs monitor critical parts (like motors, batteries, inverters, brakes, and tires) in real-time for anomalies such as overheating, vibration, or wear.

- Fault Prediction and Alerts: AI models trained on historical data can predict battery degradation, motor wear, or software malfunction and send early warnings to drivers and service centers.

- Remote Diagnostics: Technicians can access the vehicle's telemetry data remotely, enabling faster troubleshooting and proactive repairs, reducing downtime and repair costs.

- Maintenance Scheduling: The system automatically books service appointments and orders replacement parts in advance based on predicted failures.

Communication Technologies and Architecture

The Smart EV ecosystem uses various communication protocols:

- CAN Bus: For in-vehicle communication between ECUs and sensors.

- Wi-Fi/4G/5G: For real-time data transmission to the cloud.

- Bluetooth: For smartphone connectivity and user interfaces.

- MQTT/HTTP: Lightweight protocols for sensor-to-cloud communication.

The typical architecture includes:

- Sensor Layer: Collects physical parameters from vehicle components.

- Gateway Layer: Aggregates data and handles security/encryption.

- Cloud Layer: Stores data, runs analytics, and delivers insights.

- User Interface Layer: Mobile/web applications for user control and feedback.

Benefits of IoT-Enabled Smart EVs

- Improved Battery Life and Efficiency
- Reduced Maintenance Costs
- Enhanced Safety through Early Fault Detection
- User Convenience via Remote Monitoring and Control
- Lower Energy Costs and Grid Load Management
- Scalable Fleet Management for Commercial Operators

Use Cases and Real-World Implementations

- Tesla uses OTA (Over-the-Air) updates and diagnostics via IoT.
- NIO (China) offers battery health monitoring and AI-based route optimization.
- Ather Energy (India) provides predictive maintenance alerts and app-based charging control.
- EV Fleets (like Amazon's delivery fleet) use IoT for centralized monitoring, charging management, and route optimization.

Challenges and Considerations

- Data Security and Privacy: EVs generate vast amounts of personal and operational data. Protecting this information against cyberattacks is crucial.
- Connectivity Reliability: Constant, low-latency communication is required, especially for real-time alerts.
- Standardization: Interoperability across different charging stations, networks, and vehicle types is still evolving.
- Initial Cost: IoT integration adds upfront cost, though long-term savings can offset it.

Future Trends

- AI-Powered Driving Behavior Analysis for dynamic insurance pricing.

- Edge Computing in EVs for real-time analytics without relying solely on cloud.
- Blockchain for secure energy transactions in V2G systems.
- Digital Twins of vehicles for lifecycle simulation and optimization.

Conclusion

Smart EVs, empowered by IoT, are at the forefront of the transportation revolution. By enabling intelligent charging and predictive maintenance, they offer unmatched operational efficiency, cost-effectiveness, and sustainability. As IoT ecosystems mature and integrate with 5G, AI, and renewable energy networks, Smart EVs will not only redefine mobility but also become integral to future smart cities and grids.

THE INTELLIGENT CHEMICAL PLANT: SMART TECHNOLOGIES DRIVING THE FUTURE OF CHEMICAL MANUFACTURING

Mr. Aminpaul, II Year Chemical Engg.,

The chemical industry, a foundational pillar of the global economy, is undergoing a major transformation through the integration of smart technologies. The rise of **intelligent chemical plants**—facilities powered by **AI, IoT, data analytics, automation, and advanced control systems**—is revolutionizing the way chemicals are produced, monitored, and managed. These smart plants aim to maximize safety, efficiency, and sustainability while minimizing human error, energy consumption, and downtime.

1. What is an Intelligent Chemical Plant?

An intelligent chemical plant is a digitally enabled production facility where physical assets are connected via digital systems, allowing real-time monitoring, predictive maintenance, autonomous control, and data-driven decision-making. These plants combine **digital twins**, **AI-driven analytics**,

advanced process control (APC), and **industrial Internet of Things (IIoT)** technologies to operate more efficiently than traditional facilities.

2. Key Technologies Enabling Smart Chemical Plants

a) Industrial Internet of Things (IIoT)

IIoT involves a network of interconnected sensors, instruments, and devices that collect data from reactors, pipelines, valves, and other process units. Real-time monitoring of parameters such as pressure, temperature, flow rates, and emissions ensures better visibility and control over chemical reactions and processes.

b) Artificial Intelligence (AI) and Machine Learning (ML)

AI systems analyze massive amounts of data to:

- Predict equipment failures before they happen.
- Optimize chemical reaction conditions.
- Detect process anomalies and suggest corrective actions.
- Forecast demand and adjust production schedules accordingly.

c) Digital Twins

A digital twin is a real-time, virtual replica of the plant or specific equipment. It simulates chemical processes under various conditions, enabling engineers to test operational strategies, safety scenarios, and optimization plans without physical intervention.

d) Advanced Process Control (APC)

APC uses predictive models and algorithms to fine-tune process variables dynamically. It stabilizes production, increases throughput, reduces waste, and improves product quality by adjusting inputs in real time.

e) Robotics and Automation

Smart robotic systems are used for:

- Hazardous material handling.

- Automated sampling and testing.
- Valve actuation and shutdown operations. Automation reduces worker exposure to toxic environments and boosts operational efficiency.

f) Cloud Computing and Edge Analytics

While edge devices perform local analysis with low latency, cloud platforms store vast amounts of data and enable plant-wide optimization, remote diagnostics, and AI model training across multiple locations.

3. Core Functions of an Intelligent Chemical Plant

a) Predictive Maintenance

Using vibration analysis, temperature sensors, and AI algorithms, plants can anticipate equipment failures before they occur, reducing unplanned shutdowns and maintenance costs by up to 30%.

b) Real-Time Process Optimization

AI continuously analyzes operating conditions and fine-tunes the plant to maintain peak efficiency, adjusting flow rates, pressure levels, and reactant dosages based on feedback loops.

c) Energy and Resource Management

Intelligent systems monitor energy consumption and suggest improvements. Heat integration, waste heat recovery, and optimized utility management lead to energy savings of up to 20–40%.

d) Safety and Risk Mitigation

Smart systems detect leaks, abnormal vibrations, or fire hazards early. Integration with emergency shutdown systems (ESD) ensures rapid response. AI models also simulate "what-if" accident scenarios for training and prevention.

e) Environmental Compliance

Sensors track emissions in real time, ensuring adherence to environmental regulations. Data logs help in audit reporting, carbon tracking, and environmental impact analysis.

4. Benefits of Intelligent Chemical Plants

- **Enhanced Safety**: Early warning systems reduce risks to human life and the environment.
- **Operational Efficiency**: Real-time optimization minimizes downtime and energy consumption.
- **Cost Reduction**: Predictive maintenance and resource optimization reduce OPEX and CAPEX.
- **Product Quality**: Consistent process control ensures fewer defects and higher purity.
- **Faster Decision-Making**: AI provides actionable insights in seconds instead of hours or days.
- **Scalability**: Cloud-enabled platforms allow expansion to multiple sites with centralized oversight.

5. Real-World Examples

- **BASF's "Verbund" Plants** use digital twins and predictive analytics to simulate and optimize entire chemical clusters.
- **Dow Chemical** integrates real-time APC systems to stabilize critical reactions and reduce waste.
- **Shell's Smart Refineries** use IIoT and AI to reduce emissions and improve energy intensity.
- **Evonik Industries** deploys autonomous robotic inspectors to monitor hazardous areas and reduce manual inspections.

6. Challenges in Implementation

- **Cybersecurity**: The more connected the system, the more vulnerable it is to attacks.
- **High Initial Costs**: Investment in sensors, software, and IT infrastructure can be significant.
- **Data Integration**: Legacy equipment and disparate systems complicate full digital transformation.
- **Skill Gaps**: Engineers and operators require upskilling in data analytics, AI, and system integration.
- **Regulatory Hurdles**: Compliance with digital and chemical safety standards must be balanced.

7. Future Outlook

The intelligent chemical plant is evolving rapidly with innovations in:

- **AI-driven Autonomous Operations**: Plants that require minimal human intervention.
- **Green Chemistry Integration**: Smart systems that select environmentally benign solvents and processes.
- **Blockchain for Supply Chain Traceability**: Secures chemical sourcing, shipping, and compliance.
- **Augmented Reality (AR)** for training, maintenance, and process visualization in real time.
- **Sustainable Chemistry Models**: Enhanced carbon capture, zero-emission processing, and circular economy models.

Conclusion

The intelligent chemical plant marks a transformative era for the chemical industry. Through the convergence of AI, IoT, automation, and big data, these plants achieve superior performance, reduce environmental impact,

and enhance competitiveness in a volatile global market. While challenges exist, the benefits of smart, connected, and self-optimizing facilities are undeniable. As more companies embrace digitalization, the intelligent plant will become the new standard in chemical manufacturing excellence.

SMART TECHNOLOGY IN AGRICULTURE: REVOLUTIONIZING MODERN FARMING

Mr. M Gowtham, II year AGRI

Agriculture is undergoing a paradigm shift driven by the integration of **smart technologies**, collectively known as **Smart Agriculture** or **Precision Farming**. As the global population approaches 10 billion by 2050, the demand for food, fiber, and bioenergy is rising exponentially. To meet this demand sustainably, farmers and agribusinesses are adopting cutting-edge digital tools—ranging from **IoT and AI to drones and robotics**—to enhance productivity, optimize resource use, and mitigate environmental impact.

1. What is Smart Agriculture?

Smart agriculture involves the application of **advanced digital technologies** to monitor, analyze, and optimize agricultural operations. It aims to deliver real-time insights and automate decision-making across the entire agricultural value chain—from soil preparation and planting to harvesting and supply chain management.

2. Key Technologies in Smart Agriculture

a) Internet of Things (IoT)

IoT devices—such as soil moisture sensors, weather stations, and GPS-enabled machinery—gather data continuously from the field. These devices can:

- Monitor soil pH, temperature, and moisture levels.
- Track livestock health and movement.
- Control irrigation systems based on crop needs.

b) Artificial Intelligence (AI) and Machine Learning

AI algorithms analyze data collected by sensors and satellites to:

- Predict crop yields.
- Detect diseases and pest infestations early.
- Optimize planting and harvesting times.
- Recommend fertilizer and water usage.

c) Drones and UAVs

Drones provide high-resolution aerial imagery and multispectral data to:

- Assess crop health using NDVI (Normalized Difference Vegetation Index).
- Identify stressed or diseased areas.
- Map fields and manage inventory.

d) Robotics and Automation

Autonomous tractors, robotic harvesters, and smart seeders perform labor-intensive tasks with high efficiency, including:

- Precision planting.
- Automated weeding and spraying.
- Fruit picking and sorting.

e) Geographic Information Systems (GIS) and GPS

GIS maps help analyze field variability, while GPS enables:

- Site-specific crop management.
- Precision application of inputs.
- Auto-steering of farm machinery for better accuracy.

f) Big Data and Cloud Computing

Cloud platforms store and process vast amounts of farm data. Farmers access dashboards showing:

- Weather forecasts.
- Market trends.
- Equipment status and performance analytics.

3. Applications of Smart Agriculture

a) Precision Crop Farming

Farmers apply water, fertilizers, and pesticides only where and when needed, reducing waste and improving yield.

b) Smart Irrigation Systems

Sensor-based systems deliver the exact amount of water based on real-time soil moisture data and weather forecasts, saving up to 30–50% water.

c) Livestock Monitoring

Wearable sensors and collars track animal health, feeding habits, and location, allowing for early disease detection and breeding optimization.

d) Climate-Smart Farming

Smart systems help adapt to climate change by modeling scenarios and providing actionable insights on how to mitigate risks from drought, floods, or temperature extremes.

e) Farm Management Software (FMS)

Integrated platforms allow farmers to manage tasks, financials, inventory, and compliance from a single dashboard or mobile app.

4. Benefits of Smart Agriculture

- **Higher Yields**: Improved planting accuracy and pest control lead to better output.
- **Reduced Costs**: Optimized use of inputs (seeds, water, fertilizer) saves money.
- **Environmental Protection**: Less chemical runoff, reduced carbon footprint.
- **Labor Efficiency**: Automation addresses rural labor shortages.
- **Data-Driven Decisions**: Timely, actionable insights improve planning and operations.
- **Traceability and Transparency**: Helps meet consumer demand for food safety and origin tracking.

5. Real-World Examples

- **John Deere** uses AI and GPS for autonomous tractors and smart sprayers.
- **AgNext (India)** offers AI-based quality analysis for grains and milk.
- **IBM Watson Decision Platform for Agriculture** provides predictive insights using weather, soil, and satellite data.
- **Fasal (India)** uses IoT and AI for crop advisory and precision irrigation, increasing yield by up to 30%.

6. Challenges in Adoption

- **High Initial Costs**: Smart equipment and infrastructure require significant investment.
- **Lack of Digital Literacy**: Farmers in developing regions may need training.
- **Connectivity Gaps**: Rural areas often lack reliable internet or mobile networks.

- **Data Privacy and Ownership**: Concerns over who controls and profits from collected farm data.
- **Scalability**: Technology must be adaptable to both large and small-scale farms.

7. Future Trends in Smart Agriculture

- **AI-Powered Advisory Bots**: Personalized crop care advice via mobile apps.
- **Blockchain for Supply Chains**: Enhances transparency and reduces fraud.
- **5G Connectivity**: Enables real-time, low-latency data transmission for remote operations.
- **Digital Twins of Farms**: Virtual replicas to simulate and optimize operations.
- **Vertical and Urban Farming**: Smart tech enables year-round farming in cities using hydroponics and LED lighting.

Conclusion

Smart agriculture is not just a technological upgrade—it is a revolution that promises to reshape the future of food production. By harnessing IoT, AI, drones, robotics, and cloud computing, farmers can increase efficiency, sustainability, and profitability. With supportive policies, education, and infrastructure, smart agriculture can become the backbone of global food security and environmental stewardship in the 21st century.

RECENT DEVELOPMENTS
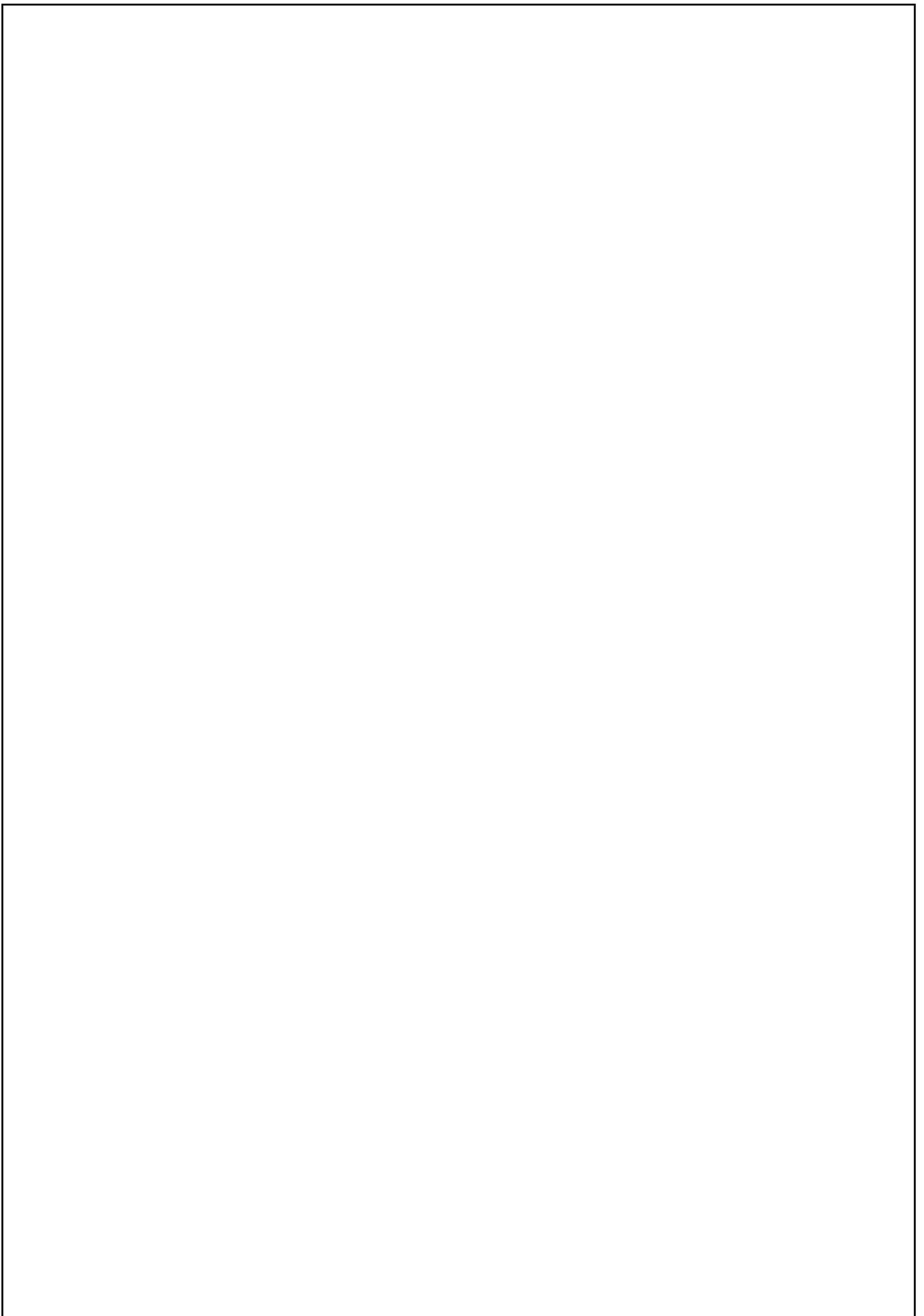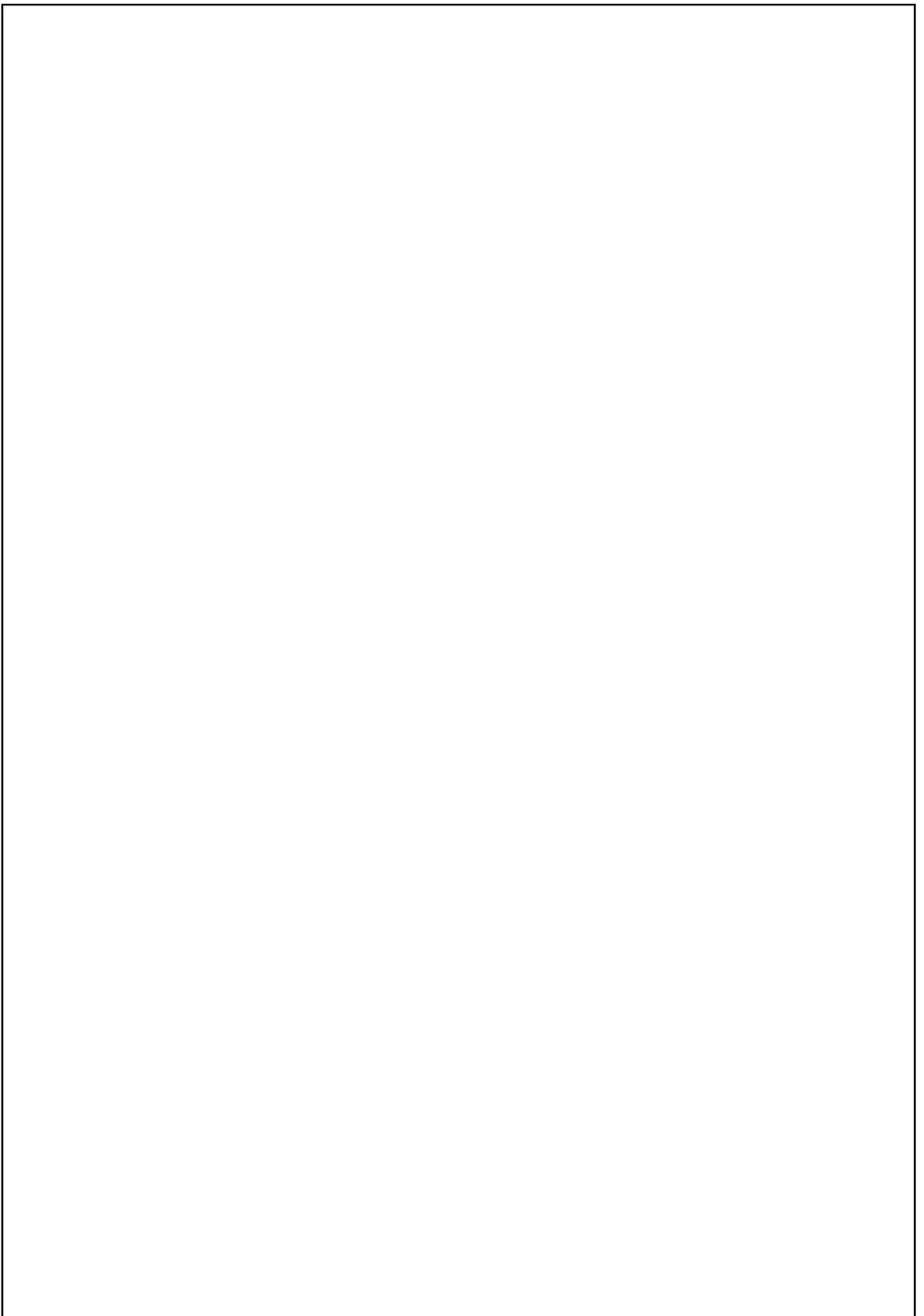
AUTOMOBILE ENGINEERING

1. Electric Cars.

In recent years, the worldwide shift to electric cars has been one of the most prominent trends in automobile industry. Environmental factors have driven the growth of zero-emission vehicle technology, and the popularity of cleaner and more environmentally friendly electric vehicles (EVs) and hybrid electric vehicles (HEVs) has increased. The battery technology and charging infrastructure required for electric vehicles are also evolving—for example, lithium-ion batteries that have certain limitations can now be replaced by solid-state batteries that have higher energy density, are safer, more stable, and cost-effective.

Challenges

Despite optimistic forecasts, 2025 will be marked by EV's slowdown. This is explained by the following factors:

- Ongoing trade tensions between China and the West;
- Competition with Chinese EVs;
- Infrastructure challenges (e.g., availability of charging stations, supply chain issues);
- High costs of electric vehicles' manufacturing and their high prices for customers.

As a result, automotive manufacturers are expected to switch to producing hybrid models—they are cheaper and more adaptable. [2; 8]
Shifting the focus to hybrid models

Hybrid vehicles are becoming increasingly popular—they combine electric power with the reliability of a combustion engine. Compared to EVs, they don't require charging, but at the same time reduce carbon emissions.
The rise of Chinese EV manufacturers

In 2025, China is going to remain a leading manufacturer of electric vehicles. Currently, they sell most of the EVs worldwide, and this year, they are expected to market more EVs than combustion engine vehicles. [8]

2. Software-Defined Vehicles.

Software-defined vehicles are those that use software to conduct all operations (braking, driving, steering, providing infotainment, etc.). This software should be regularly updated to let users take advantage of the latest technological advancements and enhance vehicle performance. This trend is gaining traction in 2025: at the recent Consumer Electronics Show, the event that showcases technological innovations across industries, software-defined vehicles were in the limelight. This means that automotive manufacturers will be producing more SDVs in the years ahead. For example, Honda is going to partner with Amazon Web Services to improve data collection and software updates and in such a way speed up the transition to SDVs. [9]

3. Self-Driving Vehicles.

Innovative manufacturers take considerable interest in the potential of autonomous driving technology since it opens new opportunities for business growth. Up-to-date, autonomous vehicles are in the early stage of development: among the 6 levels of driving automation, there are only Level 3 (conditional automation) and some Level 4 (high driving automation) vehicles available in some regions. [3].

Despite the fact that fully autonomous driving is at least several years away from the present, in 2025 and beyond, this technology is expected to be actively developed and tested, and the number of autonomous cars on roads will increase. [8]

4. Alternative Fuels.

This is one of the new trends in automotive industry, which is to some extent in conflict with electrification. However, there are still a great number of fuel-driven cars, and despite the shift to producing electric vehicles, some car manufacturers don't want to use batteries in their automobiles for some reason. So, the so-called e-fuels become a greener alternative to traditional fuel, which is also used beyond the automotive industry. E-fuels embrace e-kerosene, e-methane, or e-methanol which are produced as a result of synthesizing CO_2 emissions and using renewable CO_2-free electricity. Currently, despite their earlier ban, the European Commission has agreed to allow the selling of cars running on e-fuels after 2035, but on condition that they will have no climate impact. So, in 2025, we expect to see further developments in the area along with increased production of alternative fuels and testing them on the roads. [6; 11]

5. Automotive Supply Chain Issues.

The automotive industry is one of the most severely affected by supply chain disruptions. Currently, its greatest challenge is uncertainty and instability, which are expected to persist this year. This is explained by several factors.

- Talent shortages: automotive manufacturers suffer from high employee turnover, which continues to decline;
- The shift to electric vehicles and incorporation of advanced features in vehicles: they cause a gap between the increased demand for specific components (semiconductors, batteries) and the available supply;
- Reliance on global supply chains: the COVID-19 pandemic has revealed their vulnerability and a number of auto manufacturers are relocating their production plants;

- Geopolitical tensions: military conflicts in some regions of the world also contribute to intensifying supply chain challenges. [7]

Currently, auto manufacturers as well as auto OEMs (original equipment manufacturers) are trying to address the above-mentioned difficulties and try to reduce their dependence on the global supply chains. They are taking the following measures:

- Investing in automation;
- Diversifying the suppliers;
- Localizing production;
- Stockpiling some critical components. [12]

However, overcoming supply chain challenges takes time, so they are likely to remain in 2025. Therefore, these were the five trends transforming the automotive industry this year and beyond.

V KOUSHIK
IV YEAR AUTOMOBILE ENGINEERING

AGRICULTURAL ENGINEERING

Innovations in agricultural engineering have a huge potential to improve sustainable development by meeting the needs of the expanding global population. The environmental effect per unit of food, feed, fibre, and fuel generated is reduced by better efficiency and accuracy in the use of inputs like fertilisers and agricultural chemicals. We should put our efforts into protecting and developing the nation's natural resources of land and water in order to realise the aforementioned vision of agricultural engineering. On a mission mode, programmes that encourage agricultural mechanisation are given the weight they deserve in order to solve the challenges caused by a lack of farm workers in rural areas. Work is done on farms to improve water use efficiency in command areas and to save soil and water to stop the degradation of the land. For replenishing the ground water, cutting-edge technologies are being used.

Agricultural Engineering deals with tractor and drawbar mounted farm implement design and production, localization and planning of farm structures, soil and water management, irrigation and drainage management, processing of agricultural products, design and production of solar, wind, and water powered equipment, energy production through greenhouse gas mitigation, and waste management techniques. Recent Trends in Agricultural Engineering 1. Data management and electrification: e-agriculture for data management and electrification with a primary focus on agriculture, information and communication technology in agriculture, often known as e agriculture, is creating and implementing cutting-edge ways to employ ICTs in the rural sector. ICT in agriculture provides a variety of answers to some agricultural problems. It is regarded as a developing field that focuses on

advancing agricultural and rural development through better information and communication systems.

ICT is used in this context as a catch-all phrase for all information and communication technologies, including hardware, software, networks, mobile devices, and services. As new ICT applications continue to be tapped into in the agriculture industry, e agriculture's reach continues to expand. E-agricultural, in further detail, entails the conception, design, development, testing, and implementation of novel ICT applications in the rural domain, with a primary focus on agriculture. 2. Automation and agbots: By decreasing overlapping inputs, computing in advance the form of the field where the inputs are to be used, and comprehending the relative productivity of various sections of the field, existing geolocation technology could reduce the production of seed, minerals, fertiliser, and herbicides. Inputs can be procedurally applied at different rates across the field by tractors or Agbots.

These are employed to automate tasks related to agriculture, including planting, harvesting, weeding, and irrigation. With the help of tens of thousands of microscopic sensors, agricultural robots could monitor, forecast, cultivate, and harvest crops from the ground with essentially no human involvement. Automatic milking systems are standalone computer-controlled devices that milk dairy cattle without the need for human labour. A sophisticated herd management programme, specialised computers, and an agricultural robot work together to fully automate the milking process. The farmer may spend more time managing the farm and the herd because automatic milking removes them from the actual milking procedure. Using the information acquired by the computer, farmers may also enhance herd management.

Farmers can make the necessary adjustments to achieve the best milk yields by assessing the impact of different animal feeds on milk yield. Each cow can be watched and evaluated because the data is available at the individual level, and the farmer may be informed if there are any unexpected changes that could indicate illness or injuries. 3. Precision agriculture: Farming management focused on tracking differences within individual fields. Farmers may maximise input yields while protecting resources at greater sizes by using satellite images and sophisticated sensors.

The experts concur that User-Centered Design (UCD) in the design expert software has the potential to hasten the process of sustainable innovations by comprehending crop variability, geolocated meteorological data, and accurate sensors. The better-fitting items are simpler to use if users are more actively involved in the design process. 4. Sensors: Real-time understanding of the state of farms, forests, and water bodies is made possible by air and soil sensors. The right amount of fertiliser is required, and it is determined using high resolution crop sensors mounted in fertiliser application equipment. Utilizing infrared light, optical sensors or drones assist in determining crop health throughout the field. The vibrations in factories, farms, bridges, buildings, and other infrastructure can be monitored by sensors for the health of the infrastructure. 5. Equipment telematics: Tractors and other mechanical devices can alert users of impending failures thanks to equipment telematics.

They enable a reduction in the cost of work control and organisation, as well as a rise in the effectiveness of its utilisation. They perform round-the-clock monitoring of the equipment's operating modes and condition with the possibility of obtaining information about both general parameters (consumption, fuel level, engine temperature, etc.), as well as on specific

parameters of the operation of mechanisms and assemblies, such as monitoring the operation of hydraulics, threshing drum, filling the tank with grain, or the condition of the threshing drum. They can reduce the cost of maintenance and operation of equipment by up to 30%. 6. Livestock biometrics: Cattle biometrics employ collars equipped with GPS, RFID, and biometrics to instantly identify and transmit critical data about the livestock. Each cattle is RFID-tagged for simpler identification, allowing access to pertinent information including the bearer's location, breeder's name, the cattle's place of origin, the livestock's sex, and the dates of movement. Additionally, the programme will improve the management of animal disease outbreaks.

Urban vertical farms would raise plants or animals inside specific or mixed-use buildings. Energy-efficient lighting akin to that seen in glass homes could be used in vertical farms to supplement natural light. Numerous benefits include year-round agricultural production, weather protection, support for urban food independence, and lower transportation costs.

The act of collecting and storing rainwater for later use on the property as opposed to letting it run off is known as rainwater harvesting. Rainwater can be captured from roofs or rivers, and in many locations the captured water is directed to a deep pit by a well, shaft, or borehole, a reservoir with percolation, and captured from dew or fog with nets or other tools. Water for gardens, cattle, irrigation, and properly treated residential consumption are just a few of its uses. The water that is collected can also be used for groundwater recharging, longer-term storage, and consumption.

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AERONAUTICAL ENGINEERING

In 2025, the aerospace and defense industry is projected to grow and progress: the air travel demand has already returned to the pre-pandemic level, while geopolitical tensions cause increased defense spending in a great number of countries.

How can aerospace and defense organizations respond to increasing demand under conditions of present-day uncertainty and change? One of the solutions is the application of emerging technologies that allow A&D companies to dramatically transform the way they work and deliver value to their customers.

According to the Aerospace Industries Association's Vision for 2050 [2], some of the key technology and innovation trends in aerospace and defense industry will be:

– the rise of automation and artificial intelligence,

– wide application of augmented and virtual reality,

– the rise of Industry 4.0 (e.g., additive manufacturing and digitization).

Here's an overview of technology trends that will be driving digital transformation in aerospace and defense in 2025.

Defense Industry Digital Transformation: Technology Trends

1. Artificial Intelligence.

AI is gaining momentum in the aerospace and defense industry, and its potential suggests that areas of its successful application will grow. AI is used in the defense sector for training the military, creating advanced weapons, surveillance purposes, and providing cybersecurity. Here is an overview of current AI applications in more detail:

- AI-powered autonomous weapons and vehicle systems—crewless vehicles and submarines are already employed by the military, but replacing soldiers on the battlefield is still far from widespread implementation;
- Transforming command and control systems by performing real-time data analysis and enabling informed decision-making;
- Predictive maintenance providing the ability to forecast equipment failure;
- Detecting and mitigating cyber threats thanks to analyzing network traffic, detecting vulnerabilities, and timely responding to cyber attacks;
- Training military personnel using AI-driven simulations and virtual environments;
- Intelligence and surveillance—thanks to AI's ability to process large amounts of data, the military can increase situational awareness;
- Supporting decision-making.

Therefore, artificial intelligence has a major role in the future of the defense industry thanks to transforming military operations and increasing their effectiveness and efficiency. It means that its applications in 2025 will be more widespread and diverse.

2. Additive Manufacturing.

The defense sector benefits a lot from employing additive manufacturing, leveraging it for the following purposes.

- Replacing obsolete vehicle/military aircraft parts with 3D printed ones: This is especially relevant for Air Forces that follow the example of Boeing and Airbus and have necessary parts 3D printed instead of the ones manufactured in a traditional way—it's much faster and more cost-saving to print these necessary parts.

- Building various structures, from bridges to shelters: The technology can not only enable faster design but also speed up all building processes and make them much less labor-consuming.
- Reducing the weight of defense equipment: 3D-printed parts and components are more lightweight, require less material than the ones traditionally manufactured, and are less costly.

Therefore, additive manufacturing is and will be actively used by the military to quickly create a variety of things they require—from "printing" vehicle parts to building necessary structures. The technology will also contribute to overcoming supply chain issues thanks to deploying on-site 3D printers. In 2025, additive manufacturing will continue to play its transformative role in the defense sector, facilitating cost optimization, promoting innovation, and operational agility.

3. Advanced Defense Equipment.

With the rapid development of digital technologies, defense equipment is becoming more and more sophisticated, which includes the use of directed energy and hypersonic weapons, space militarization, and more. In addition, in response to the demand to achieve net-zero emissions, the defense sector is looking for ways to employ electric propulsion and greener alternatives to traditional fuels to reduce their carbon footprint. Finally, the progress in biotech and nanotechnology research has made it possible to create self-healing armor which becomes a game-changer for soldier protection.

4. Internet of Military Things.

The Internet of Military Things is the other game-changer for military operations. Being an interconnected network of devices, technologies, and the internet, it facilitates increased automation, improves decision-making, and secures real-time data-sharing. IoMT implies that sensing and computing

devices are worn by soldiers or embedded in equipment for collecting a variety of data. Therefore, tanks, ships, drones, soldiers, and operating bases are connected in a network, which improves situational awareness and field understanding and facilitates faster and more effective decision-making. Future developments and applications of IoMT are expected to involve the integration of sensors, vehicles, robots, and weapons.

5. Robotics & Autonomous Systems.

Robotics and autonomous systems have huge potential for the defense sector, as they make it possible to take military conflicts to the next level, mainly thanks to increasing situational awareness and reducing soldiers' physical and cognitive workload. Being used both on land and sea, they facilitate freedom of maneuver and at the same time reduce risks faced by soldiers. For example, robots and autonomous systems can assist in landmine clearance, explosive ordnance disposal, search rescue operations, or undersea navigation and surveillance.

Increased use of drones

Leveraging drones in military operations is worth giving particular attention to. Their effectiveness has been proven in recent military conflicts, particularly in Ukraine. Drones travel long distances and can be used for surveillance purposes, to hit specific areas, or to suppress air attacks. However, the main reason for their extensive use is their low cost and effectiveness. Their production is cheaper than the production of other weapons. At the same time, they cripple the enemy seriously.

6. Immersive Technologies.

The main advantage of leveraging immersive technologies (augmented and virtual reality) is that the military can apply them for equipment, flight, and weapons training. When used for training soldiers, VR and AR provide safer

training environments, terrain diversity and customization, better access to mission rehearsals as well as enhanced spatial awareness. AR can also be used for training fighter pilots, as it simulates threats that a pilot has to fight with. Immersive technologies make soldiers more effective, e.g., wearable glasses can provide them with a variety of data for more effective decision-making. Finally, immersive technologies can help with more effective mission planning by providing 3D terrain maps and simulated environments.

7. Achieving Cyber Security.

Cybersecurity remains one of the biggest concerns and sustained trends for the defense sector, as it's often vulnerable to cyber-attacks that have become more frequent in recent years. As defense organizations adopt advanced technologies, the need for cybersecurity becomes more and more urgent, as they store and share large amounts of data. So, the defense sector is expected to use digital technologies and advanced detection systems to protect sensitive data, identify potential cyber threats, and mitigate them before they cause damage. However, in addition to protecting from cyber attacks, the military are working on developing offensive cyber warfare including malware, ransomware, and phishing attacks.

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MECHANICAL ENGINEERING

Sustainable Engineering and Renewable Energy

Sustainable engineering is the integration of sustainability principles into the design, operation and disposal of mechanical systems and products. Sustainability involves focus on reducing environmental impact, enhancing efficiency and promoting the use of renewable resources. Increasing awareness of climate change and environmental degradation is driving the demand for sustainable engineering solutions.

Governments, industries and consumers are seeking more eco-friendly products and energy sources. As a mechanical engineer, you may be involved in designing and refining energy-efficient technologies such as more effective wind turbines and improved solar panels and geothermal energy systems.

Digitalization and Industry 4.0

Digitalization and Industry 4.0—the process of integrating digital technology into industrial and manufacturing processes—are transforming mechanical engineering, leading to what many call the Fourth Industrial Revolution. This revolution is characterized by the smart factory, where machines and products are connected to devices that allow for real-time tracking to optimize production efficiency and performance. Digital technologies are being incorporated into all aspects of engineering, from design and prototyping to the manufacturing process and maintenance. By combining robotics, real-time data and artificial intelligence, smart factories can make adjustments as soon as they're needed, often without the need for human intervention.

The Internet of Things (IoT)

The Internet of Things involves embedding sensors, software and other technologies into physical mechanical systems, allowing them, through wireless connectivity, to exchange data with other devices and systems over the internet. For example, by equipping inventory with sensors, organizations can track it from the time it's produced until it's delivered to the buyer. Engineers can also use IoT technology on factory machines to monitor performance and receive alerts regarding maintenance issues before an outage or failure. This integration results in smarter, more responsive systems that can adapt to changing conditions and user needs, such as statistical usage data on a product that engineers can use to improve subsequent designs.[9]

Automation and Robotics

Automation employs control systems, such as computers or robots, and information technologies to handle different processes and machinery in an industry to replace human intervention. In mechanical engineering, this translates to increased efficiency, higher production rates and improved safety in manufacturing processes.

Robots are used to perform complex tasks and those that are dangerous, tedious or in need of precision beyond human capability—assembling small, intricate components, for example, or drilling in dangerous areas. They protect humans and increase productivity and consistency in assembly operations.

Additive Manufacturing Through 3D Printing

Additive manufacturing—specifically, 3D printing—may not seem trendy or revolutionary. The first 3D printer was invented in 1981, but they weren't commercially available until 2006.[10] Though the technology has been around for years, we're seeing increasingly sophisticated new advancements in uses, techniques and materials. Niche companies, such as Relatively Space, are using 3D tech to custom-print parts on a low-volume basis. The Terran R rocket, for example, is the world's first 3D-printed, reusable rocket.

One of the earliest and still primary uses of 3D printing is rapid prototyping. It allows designers and engineers to create, test, and modify prototypes quickly, dramatically reducing the development time and cost. Additionally, just-in-time production eliminates the need for expensive volume requirements and inventory storage.[12]

Advanced Materials and Nanotechnology

Nanotechnology is revolutionizing mechanical engineering by enabling the development of advanced materials with unprecedented properties. Lightweight and high-strength new materials, such as carbon fiber composites and advanced alloys, are being designed for enhanced durability and performance, significantly benefiting the aerospace and automotive sectors, among others.

Nanotechnology allows mechanical engineers to manipulate materials at the molecular level to achieve desired performance characteristics, leading to innovative solutions in product design and manufacturing. Nanomaterials, with their exceptional strength, conductivity and thermal properties, are

finding applications in many industries, including electronics, energy storage and biomaterials.

Artificial Intelligence (AI) and Machine Learning (ML) Applications in Optimization and Decision-Making

AI and ML algorithms can be used to optimize design processes and create more efficient and effective mechanical systems. These algorithms can analyze vast datasets to identify the best design parameters, considering factors like material properties, environmental impacts and manufacturing constraints. In the manufacturing industry, AI and ML help to optimize production processes, increase production efficiency, reduce waste and improve quality. They can predict the outcomes of process changes, guide decision-making and automate routine tasks.

Intelligent Control Systems and Autonomous Machinery

AI allows for intelligent control systems that can autonomously adjust operating parameters in real-time for optimal performance. These systems are used in various applications, from climate control in buildings to adaptive control in manufacturing processes.

AI and ML power autonomous machinery, such as self-driving vehicles, drones and robotic systems. In mechanical engineering, benefits of these technologies include automating jobs that require high precision, improving safety by reducing human errors and advancing human knowledge through applications such as deep space exploration.

Predictive Maintenance and Condition Monitoring in Mechanical Systems

AI and ML are advancing maintenance strategies in mechanical engineering through predictive maintenance and condition monitoring. These technologies use data from sensors and historical records to accurately predict machine failures, allowing for proactive maintenance to prevent breakdowns. Continuous monitoring of equipment conditions with AI algorithms—analyzing factors such as vibration, temperature and sound—facilitates early issue detection, reducing downtime and maintenance costs. Implementing AI in these areas improves the reliability of mechanical systems and their safety by averting potential hazardous failures.

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MECHATRONICS ENGINEERING

Mechatronics, a multidiscipline approach in Engineering and Technology, emerged in Japan at the end of the 1960s and has undergone extensive research to reach its current status. Its contribution to manufacturing, medicine, textile construction, and energy is enormous. It paves the way for automation in the above-mentioned domains and enhances quality and productivity. In this article, a review of the current trends in Mechatronics in the above-mentioned domains has been investigated and articulated.

Mechatronics in Manufacturing

Mechatronics has a significant contribution to manufacturing, as shown in Figure 1. Automation has taken a major role in manufacturing and robots are performing the majority of jobs that were once accomplished by skilled workers. Implementing smart machines by incorporating the Internet of Things (IoT) and Artificial Intelligence (AI), leads to precise manufacturing and attaining the zero waste target. Nowadays, the manufacturing system is much improved in interconnectivity and the manufacturing personnel can see the real-time process and take decisions accordingly.

Figure 1. Mechatronics in advanced manufacturing

In recent days, 5G connectivity has taken on the role of lightning-fast communication. 5G also plays an important role in industry decisions and problem-solving. Along with 5G, IoT allows us to send communication to users who are not on-site.

Mechatronics in Medicine

Mechatronics has emerged as an eminent sector in healthcare technology (Figure 2). The major milestones of Mechatronics in the medical field include deep learning algorithms in disease diagnosis, rehabilitation robot development, and bio-signal devices for various applications. Technology such as MEMS (Micro Electro Mechanical Systems) offers the miniaturization of devices to fabricate minute devices for medical and biological applications. This paves the way for an effective drug delivery system, which is a promising alternative to conventional methods.

Figure 2. Mechatronics in medicine

These techniques target only the affected cells or tissues, significantly reducing the side effects of drugs commonly used in certain types of treatments such as cancer, etc. These kinds of technical treatments have a high impact on retinal diseases. Normally, sending drugs to the brain is difficult, but by

implementing the nano drug delivery system, it is possible to reach the most complex parts of the brain. Similarly, it is commonly known that the different organs in the human body have different pH values, and the drug can be targeted toward the particular organ by tracking the specific pH value. Apart from this, there is recent research in nano vaccines, which can be combined with bacterial DNA, which is programmed to trigger the immune system.

Mechatronics in Textile

A recent study shows that textiles, footwear, and home textiles are the fourth highest priority worldwide, next to food, houses, and transport. Mechatronics technology is extremely important in textile supply chain management, and it has recently made inroads into various textile processing such as printing, knitting, and embroidery as shown in Figure 3. Unsupervised decision-making is integrated with the textile machinery to create unsupervised decision-making without human intervention. The Epson F7200 printing machine, border lace-making machine, and RX300 spinning frame are a few examples of mechatronics machinery for various processes in the textile sector. Today, the textile industries have multiplied several times more than in the previous decades to meet the huge demand, and textile mechatronics enhances production growth in a significant way.

Figure 3. Mechatronics in Textile

Mechatronics in Construction

Mechatronics in construction (figure 4) mainly focuses on the development of smart buildings where the building can utilize energy at an optimal level and also depends on renewable forms of energy generation. The advanced robot dynamics support the clearing of construction debris and are also involved in construction activities. Mechatronics involved in these civil activities is more environmentally sustainable. They are autonomous and do not require an operator for operation. Imaging technology is one of the most advanced operations in the construction industry. Here, special drones are involved in imaging the construction site and giving details about the work site. The Artificial Intelligence (AI) incorporated into the system enables it to predict the essential tasks to be performed on the site. These provisions help with remote monitoring of the construction site. Many difficult tasks are performed by robots, such as painting drones, which can reach places that a manual laborer would find difficult to reach. In the case of road construction, autonomous vehicles are implemented in laying the roads and these vehicles are used in regions where the traffic is very high, thereby preventing accidents to a great extent.

Figure 4. Mechatronics in Construction

Mechatronics in Energy

Current global-level issues such as carbon emissions and global warming due to the usage of non-renewable energy lead to a significant change in climatic conditions (Figure 5). These changes have an adverse impact on the economy of the nation due to agricultural degradation and a decline in the production sectors such as textiles, manufacturing, etc.. In order to overcome these issues, a sustainable energy sector should be implemented worldwide. There are various challenges encountered in implementing the renewable energy sector. These constraints can be successfully overcome by the usage of various Mechatronics systems. Mechatronics systems are widely used in energy optimization in solar, wind, and wave energy.


Figure 5. Mechatronics in Energy

In the solar sector, the Mechatronics system plays an important role in optimal energy conversion by effective tracking of solar radiation and also in the development of smart grid technologies. Further, in the wind and wave sectors, the Mechatronics system takes the responsibility of maintaining the dynamics of the plant to match the incoming wave and wind conditions. The system has the ability to tune itself to maintain optimal power extraction.

Mechatronics is a multidiscipline approach that includes computer science, production systems, electrical, and electronics and has tremendous application in various sectors. In the near future, mechatronics will contribute to every part of life. The recent advancements in the engineering and technology sectors pave the way for the development of sustainable products that will drastically reduce the carbon footprint of the entire globe and lead to secure and sustainable development.

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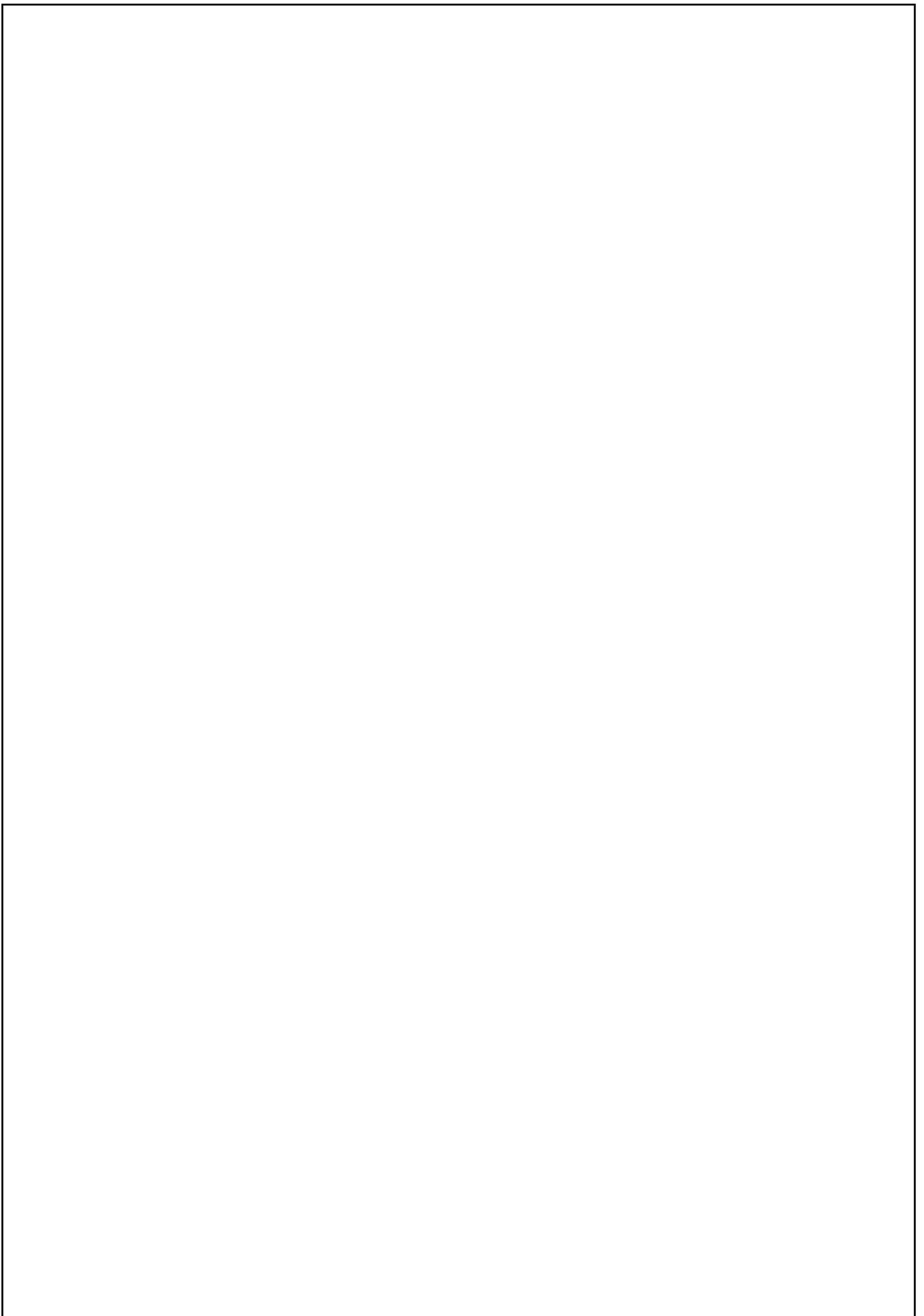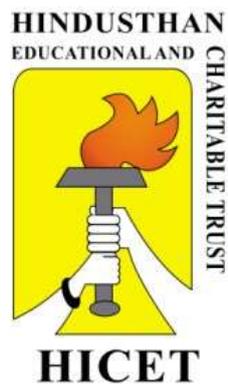
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