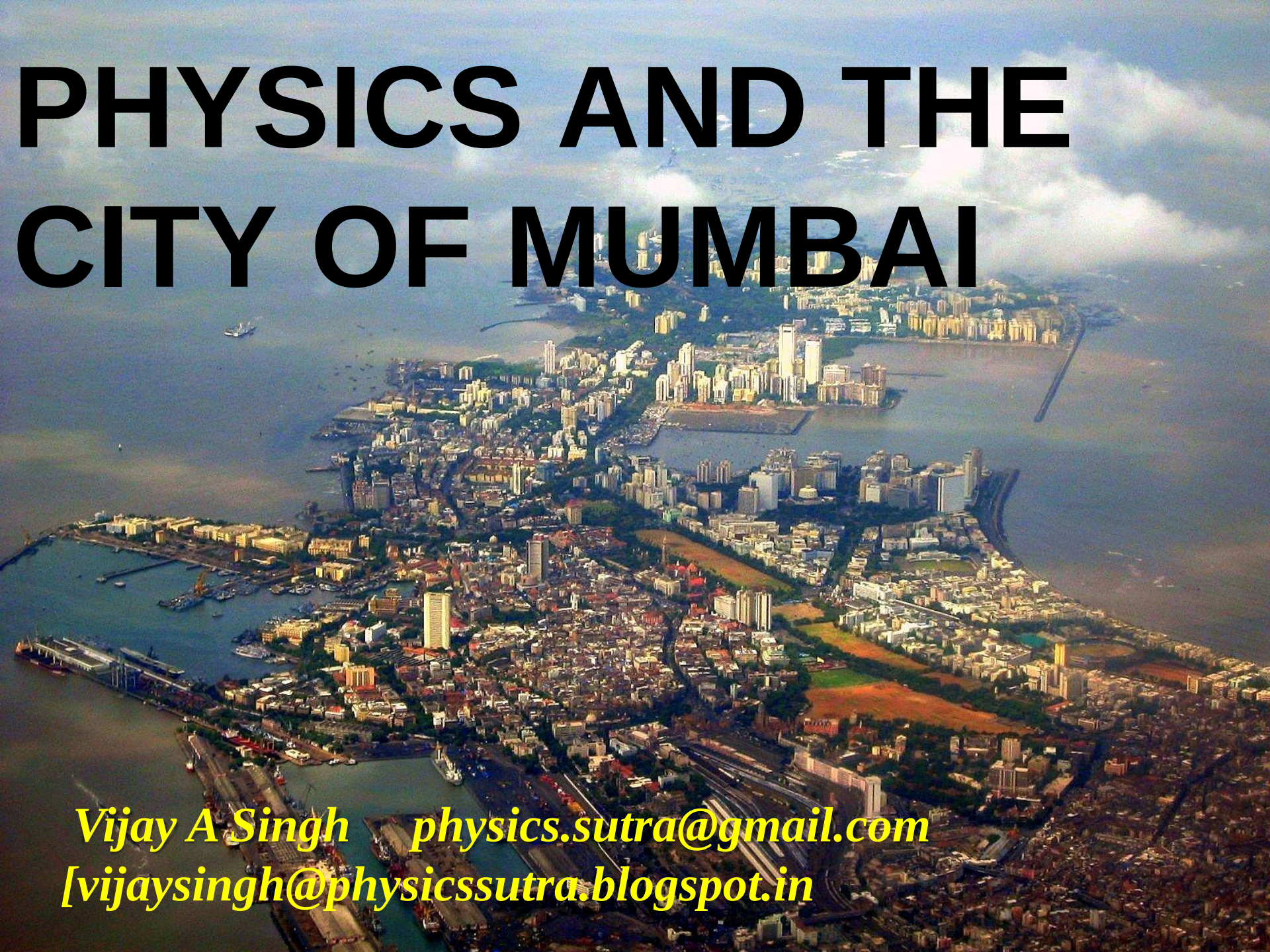
PHYSICS AND THE CITY OF MUMBAI



Vijay A Singh physics.sutra@gmail.com
[vijaysingh@physicssutra.blogspot.in

खुशनुमा बॉम्बे तुझ पे पीरों का साँया,
जैसा सुना था, तुझे वैसा ही पाया !!

Why “Minarets” ??

It acts as a *Lighthouse …*

*"***MINARET** (*manāra*), a tower, usually attached to a mosque, from which the muezzin (*moʾaḏḏen*) summons Muslims to prayer. In Arabic, *manāra* originally denotes a lighthouse or signaling tower at sea."

HORIZON

Pythagoras' theorem $a^2 + b^2 = c^2$

$$x^2 = (R+h)^2 - R^2$$

$$x = \sqrt{2Rh}$$

For Minaret, $h = 85\,ft = 25m$

$$\sqrt{2Rh} = \sqrt{2 \times 6400 \times 25 \times 10^3}$$

$$= 10^3 \sqrt{2 \times 6.4 \times 25}$$

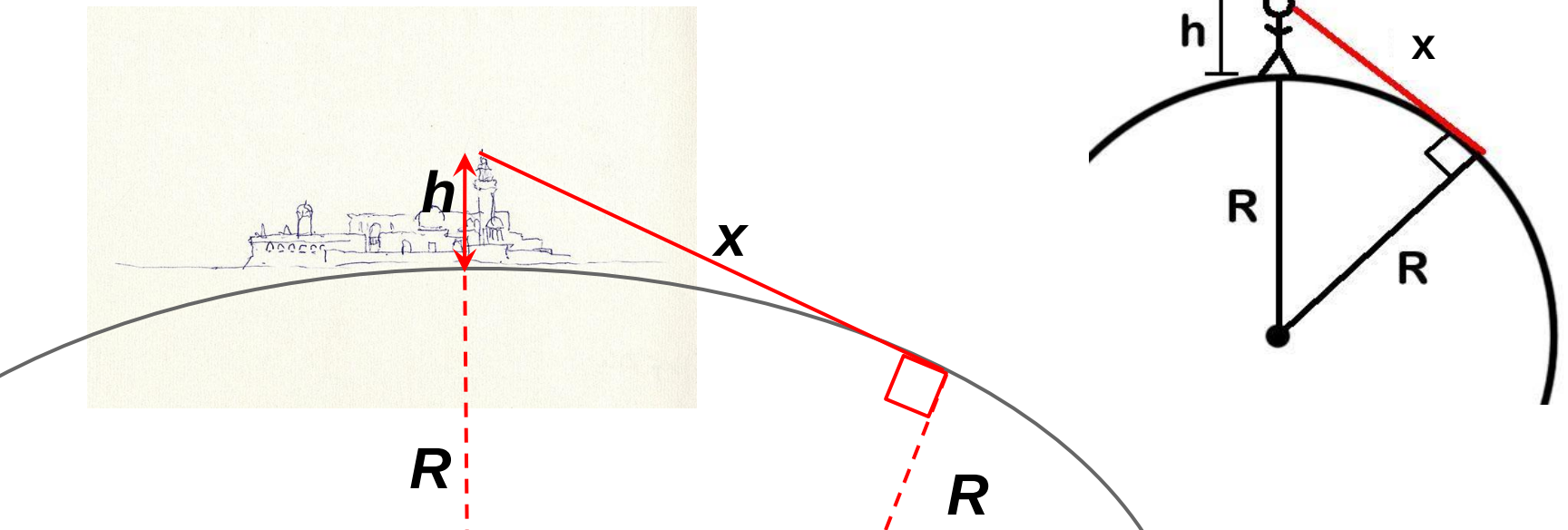
$$= 17.89 kms$$

For Human being, $h = 6\,ft = 1.83m$

$$\sqrt{2Rh} = \sqrt{2 \times 6400 \times 1.83 \times 10^3}$$

$$= 10^3 \sqrt{2 \times 6.4 \times 1.83}$$

$$= 4.84 kms \approx 5 kms$$



A Comparison

Mumbai History

- 1661: Portuguese Princess Catherine of Braganza brings Bom Bahia to King Charles II of England as part of her marriage dowry
- 1668/1669: British East India Company leased the seven islands of Mumbai from Charles II
- 1687: British East India Company transferred its headquarters from Surat to Mumbai. making it head of all the Company's holdings .
- 1802 Treaty of Bassein (Vasai)

World Scientific History

- 1662: Robert Boyle: Boyle's law of ideal gas
- 1665: Philosophical Transactions of the Royal Society first peer reviewed scientific journal published.
- 1687: Newton: The publication of Newton's Principiia, Law of motion, law of universal gravitation, basis for classical physics
- 1802 Thomas Young –definitive proof of the wave nature of light

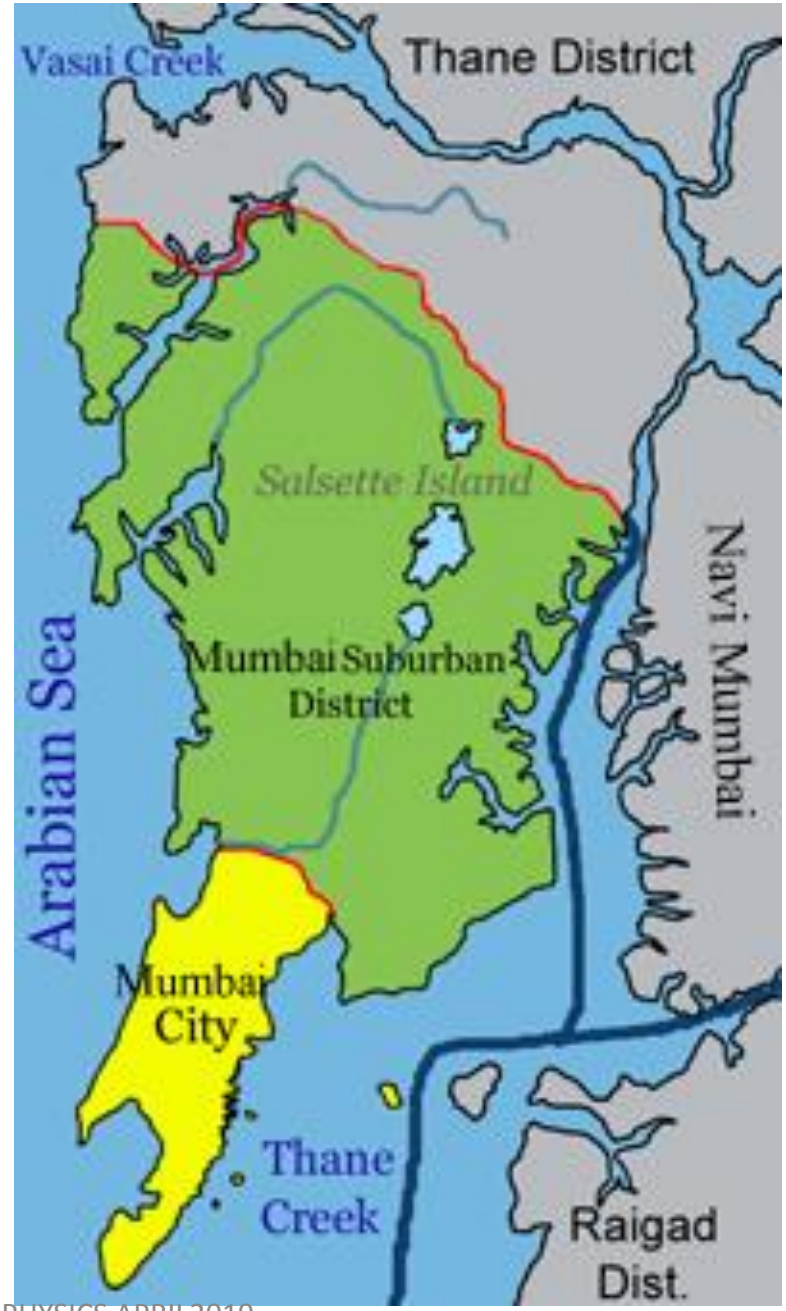
Geography

- Mumbai consists of **two** distinct regions:

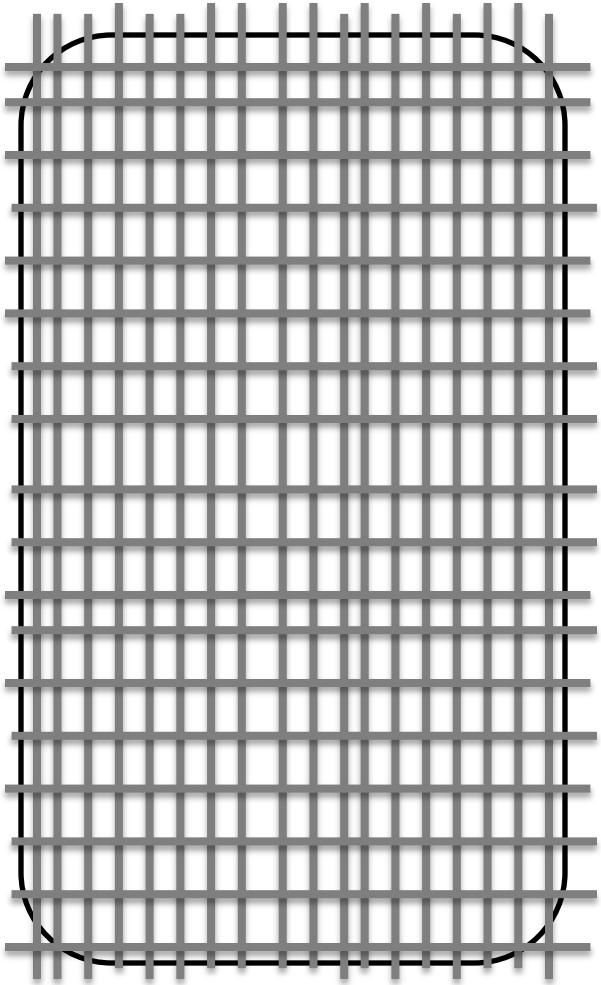
i. **Mumbai City district (South Mumbai) spans 67.79km^2 (26 sq mi)**

ii. **Mumbai Suburban district spans 370 km^2 (143 sq mi)**

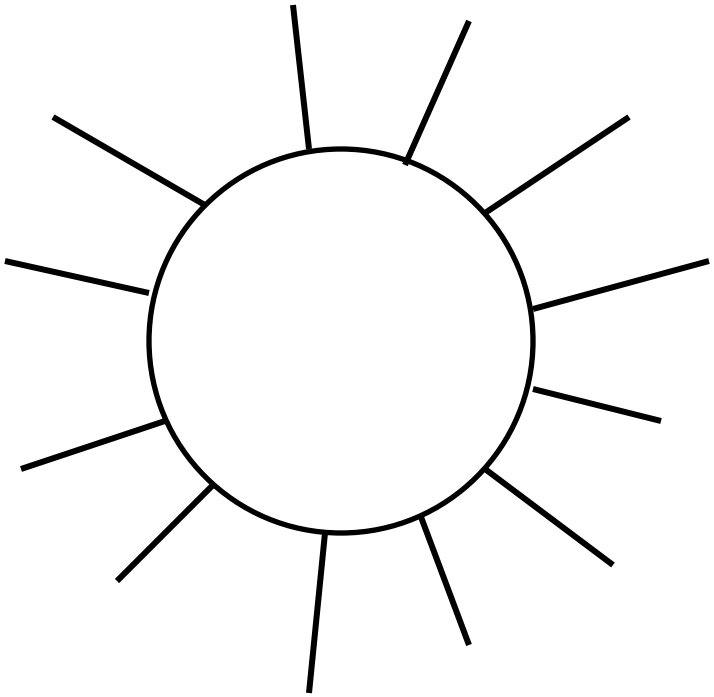
- Population of Mumbai: **18 million and growing!**
- Population Density: Approximate **40,000 persons per sq km**

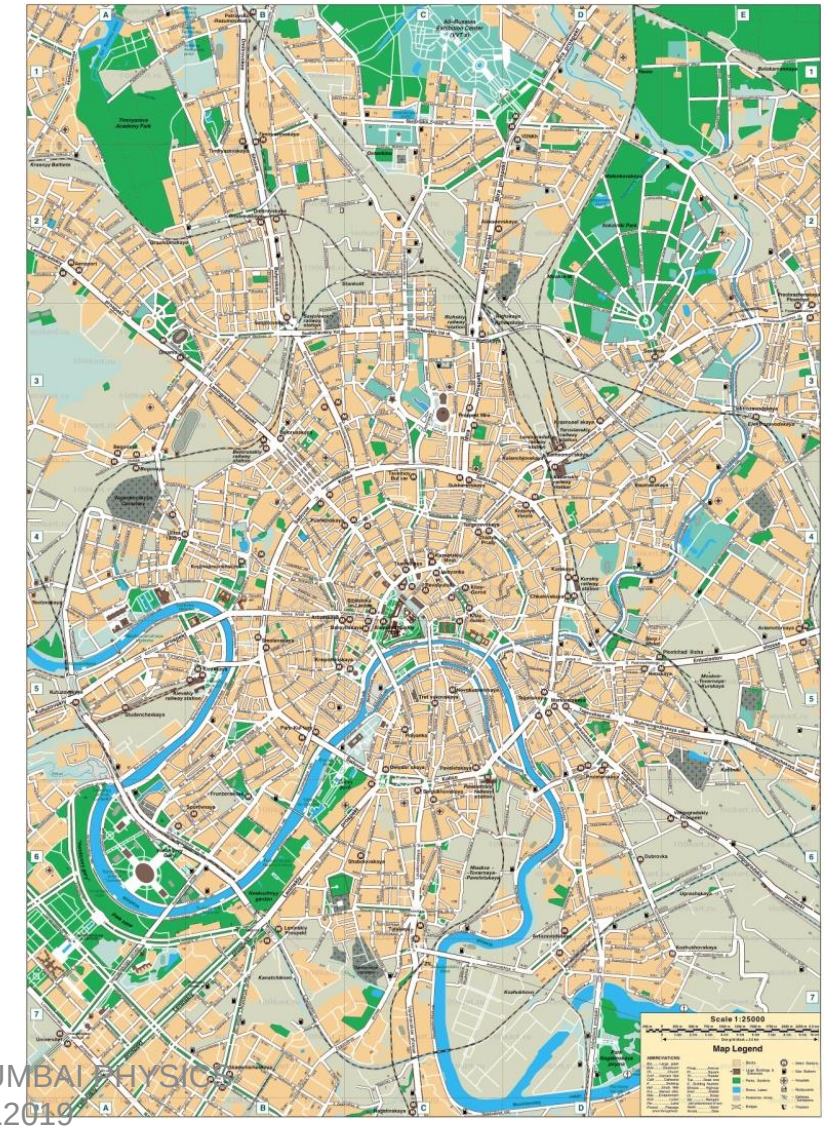


Manhattan Metric



Moscow Metric





Maps of
Mumbai & Delhi (Connaught Place)

Living in Mumbai for over a decade?

Some pivotal experiences.....

MUMBAI TRAINS

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First train from CST to Thane, April 16,1853 (161 years ago)

- 34 kms
- 14 – coach steam engine
- Halting at Byculla & Sion and at another place to fill water for the engines
- Exactly 1 hr 15 mins journey

2014 – Today

- Fast train:

  45 mins & 4 halts

  (Byculla, Dadar, Kurla and Ghatkopar)

- Slow train:

  1 hour, 18 stations

KNOWING SOMEONE CLOSE SERIOUSLY HURT IN A RAILWAY ACCIDENT

What is the speed of a Fast Train ?

Approximately 90 km/h = 25 m/s

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If you fall as far as 100 m in front of the train while crossing the track, can you be saved?

200 m ?

300 m ?

400 m ?

500 m ?

Max. de-acceleration = -0.5m/s^2

$$v^2 = u^2 + 2as$$

$$v = 0$$

$$u = 25$$

$$a = -0.5$$

$$s = -\frac{u^2}{2a} = +\frac{25 \times 25}{2 \times 0.5} = 625$$ > half a kilometre ! m !

And you haven't even considered the driver's reaction time.

Reaction time = Approx. 2 sec

$s_1 = 2 \times 25 = 50$ m

$s + s_1 = 675$ m

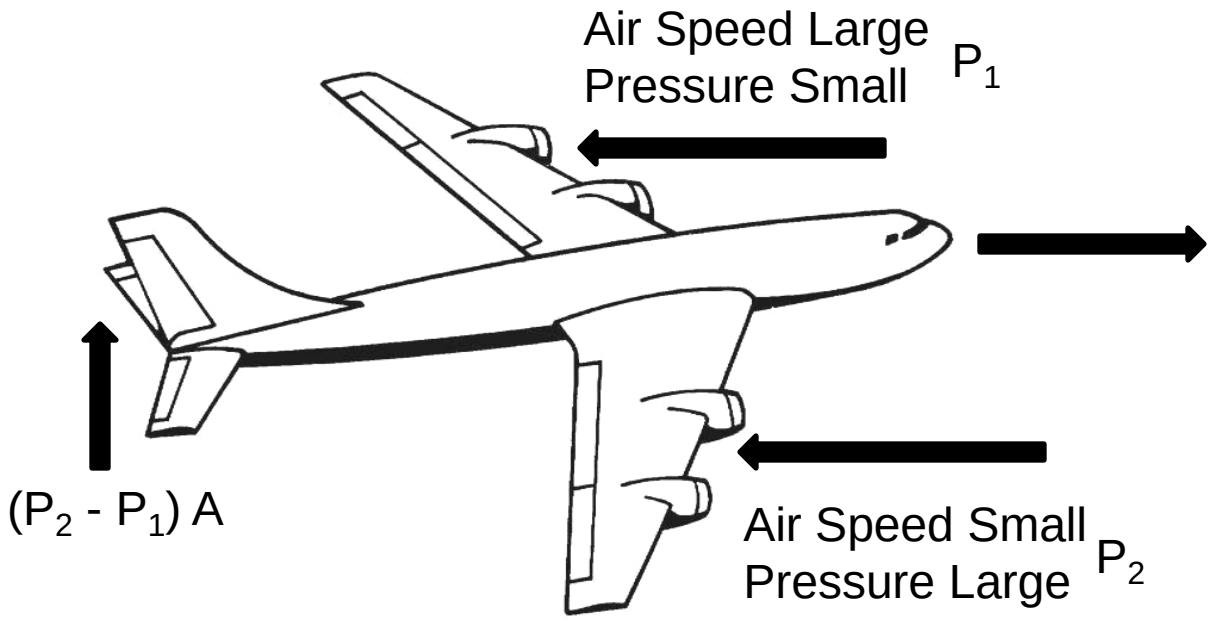
NEVER EVER CROSS THE RAILWAY TRACKS !!

BERNOULLI'S PRINCIPLE

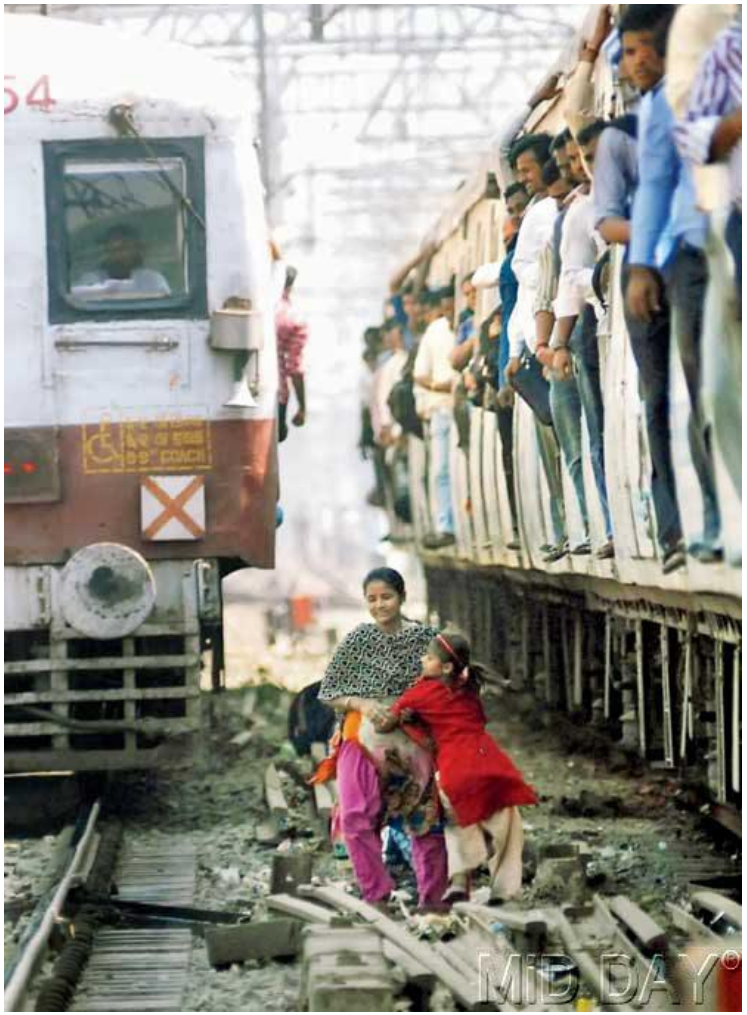
Standing near the tracks !

Is it safe ? NO !!

Why? One reason is from a **Law of Fluid Mechanics.**



People standing near moving train track



August 18 2018 7:18 pm, Thane Station

Hameed Jewal's Fatal De-boarding from a Local Train

Hameed Jewal was from Bangla Desh
– far, far away from HOME

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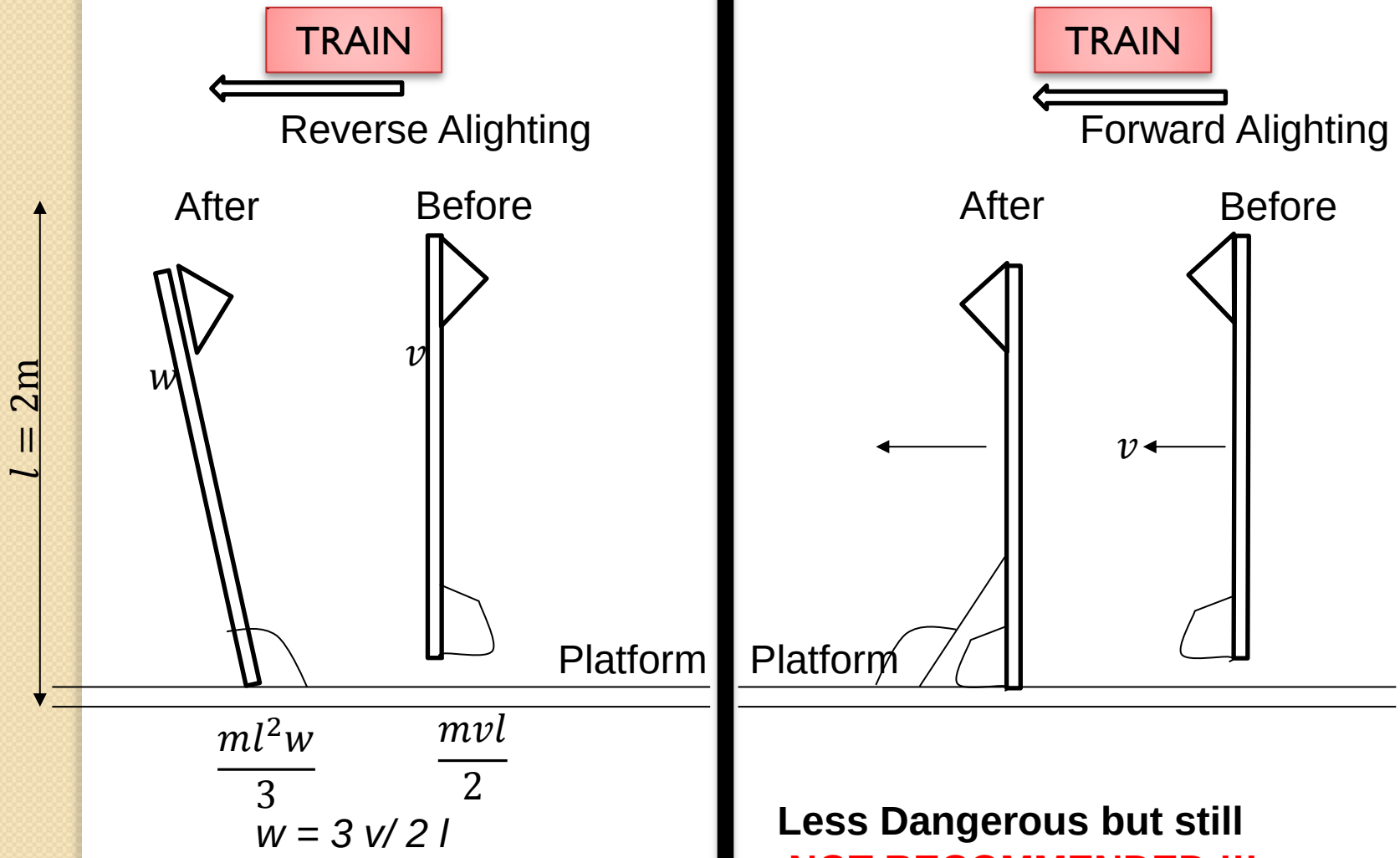
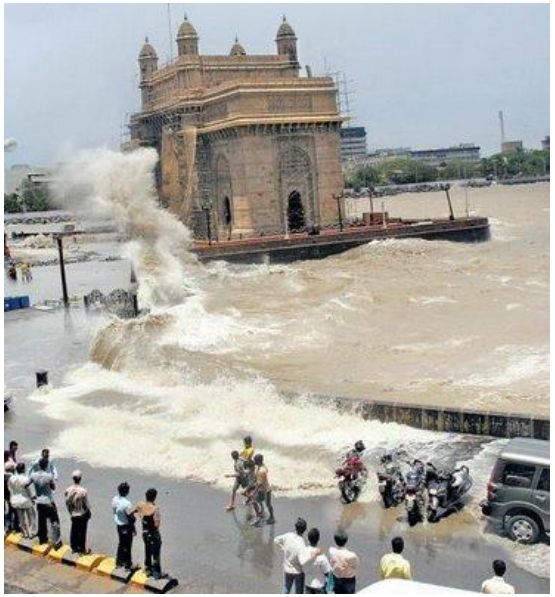
ALIGHTING FROM A MOVING TRAIN

$v =$ slow 7 kmph $= 2$ m/s and $w = 90$ °/s



Back of head comes crashing down in 1 second !

Less Dangerous but still NOT RECOMMENDED !!!



GETTING WET AT LEAST ONCE EVERY MONSOON

Mumbai Rains

Some were trapped inside their cars. Let us understand how.

Average Pressure exerted by water on the car door = $\frac{\rho g h}{2}$

= 5000 Pa

Force on the car door by water = Pressure x Area

= 5000 x 1 m^2

= 5000 N

And, you can exert about 1000 N from inside (Body mass x g).

So you are trapped !

Why is the Mumbai sea-shore so popular?

CONVECTIVE COOLING

Law of Convection

Heat is generated in the body due to metabolism and needs to be disposed off.

$$\frac{\Delta Q}{\Delta t} = K_c A_c (T_s - T_L)$$

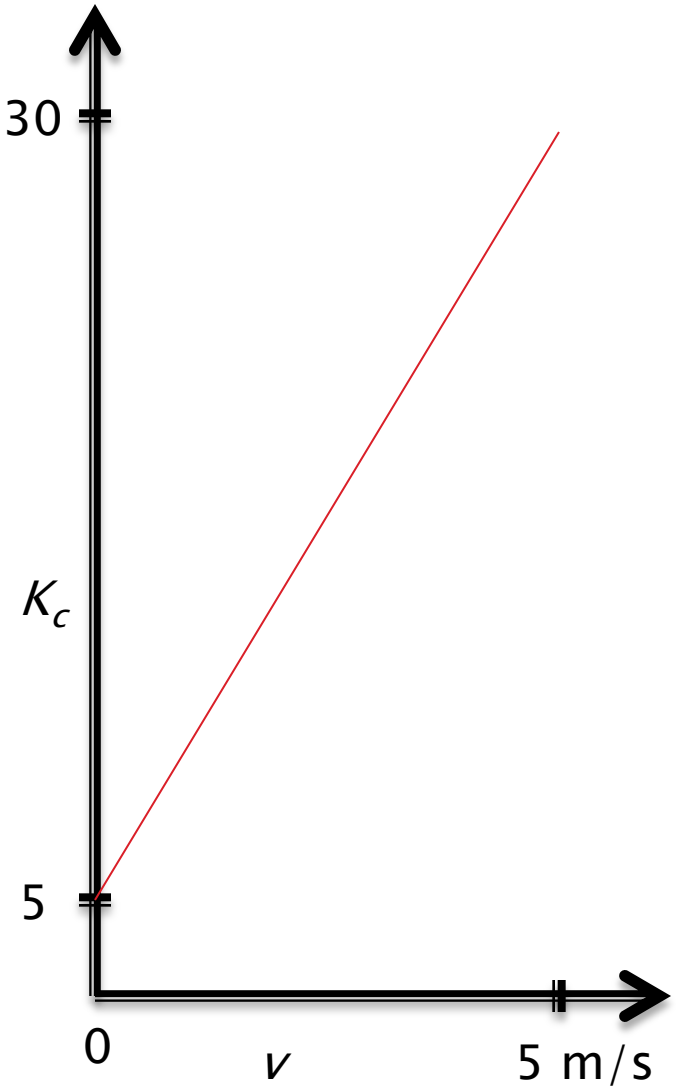
$\frac{\Delta Q}{\Delta t}$ = the heat energy (ΔQ) transported in time (Δt)

A_c = exposed body area

T_s = skin temperature (37°C)

T_L = atmosphere (33°C)

K_c = constant for convective cooling =5 Kcal/m^{2}hr



A body surface area = 1.5 m^2

$$A_c = \frac{2}{3}A = 1m^2$$

$$\frac{\Delta Q}{\Delta t} = 5 \times 1 \times 4 = 20\,Kcal/hr$$

Body generates 100 Kcal/hr

So, 100 – 20 = 80 **Excess Heat ? !**

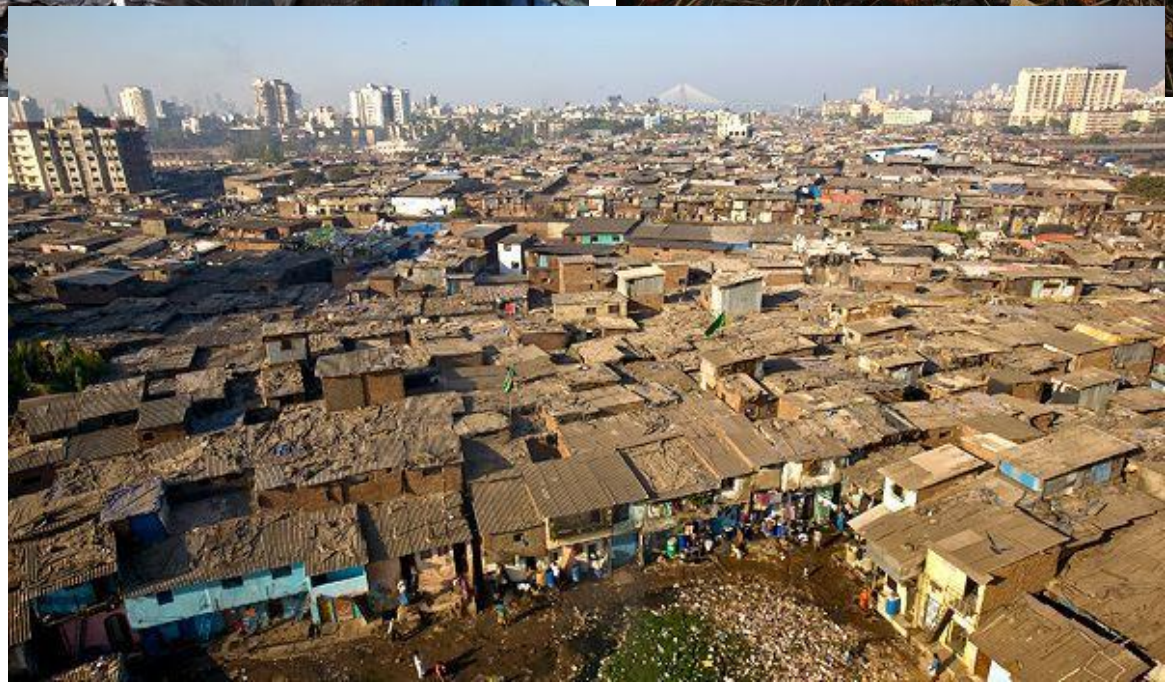
Now, even if a wind of 3 m/sec is blowing,

$$v = 3\,\text{m/sec}$$

then, $K_c \neq 5, = 20\,\text{Kcal/m}^2$

$$\therefore \frac{\Delta Q}{\Delta t} = 80\,\text{Kcal/hr}$$

This suffices and is akin to
Outside temperature being more like 20°C and not 35°C !



FACING A HOUSING PROBLEM

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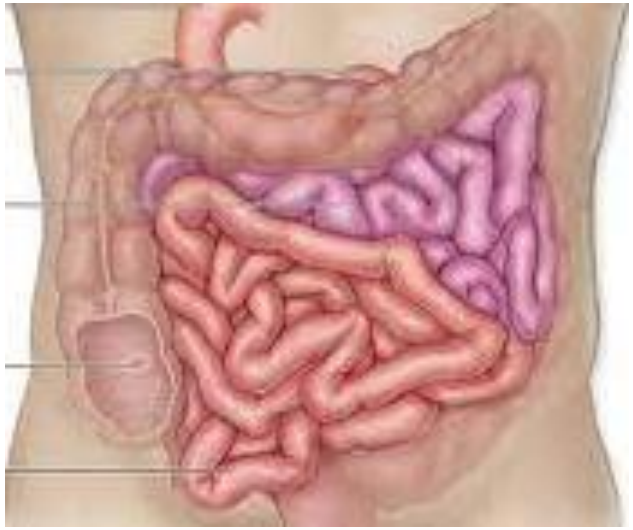
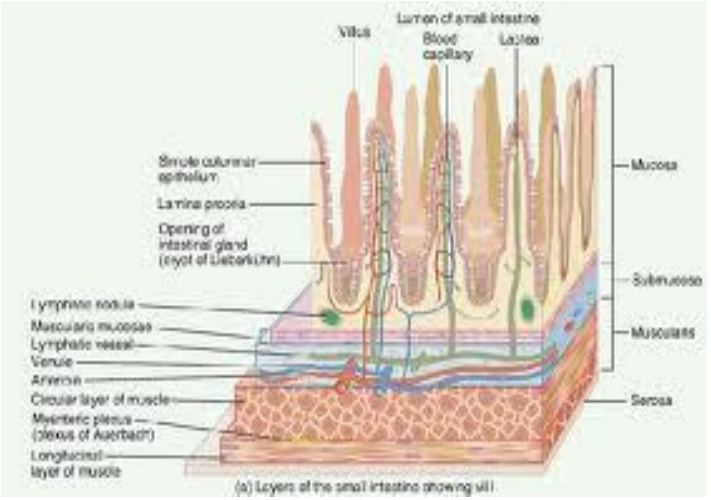
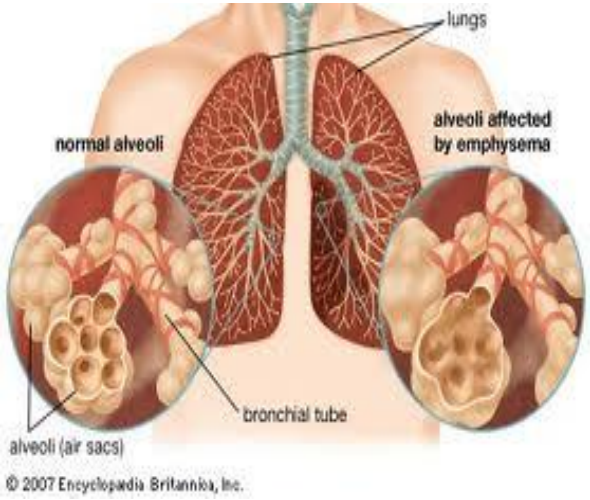
UNITED COLORS OF BENETTON
RUBY





(a) Layers of the small intestine showing villi



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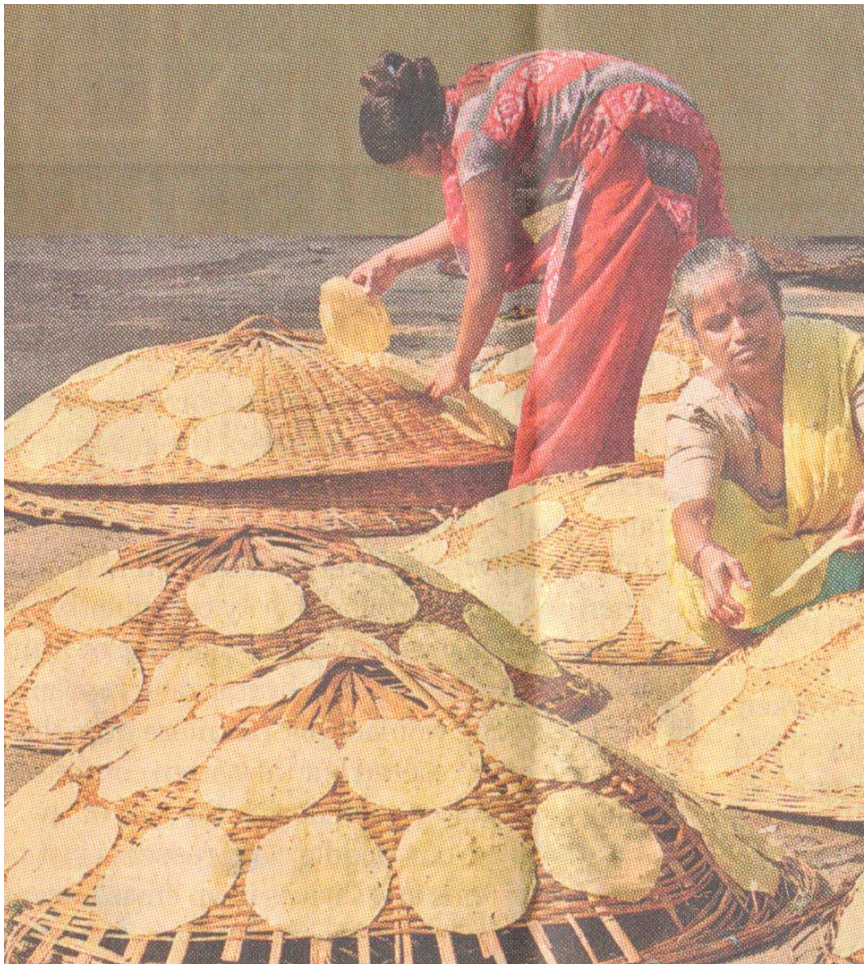
Surface to Volume



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Mumbai

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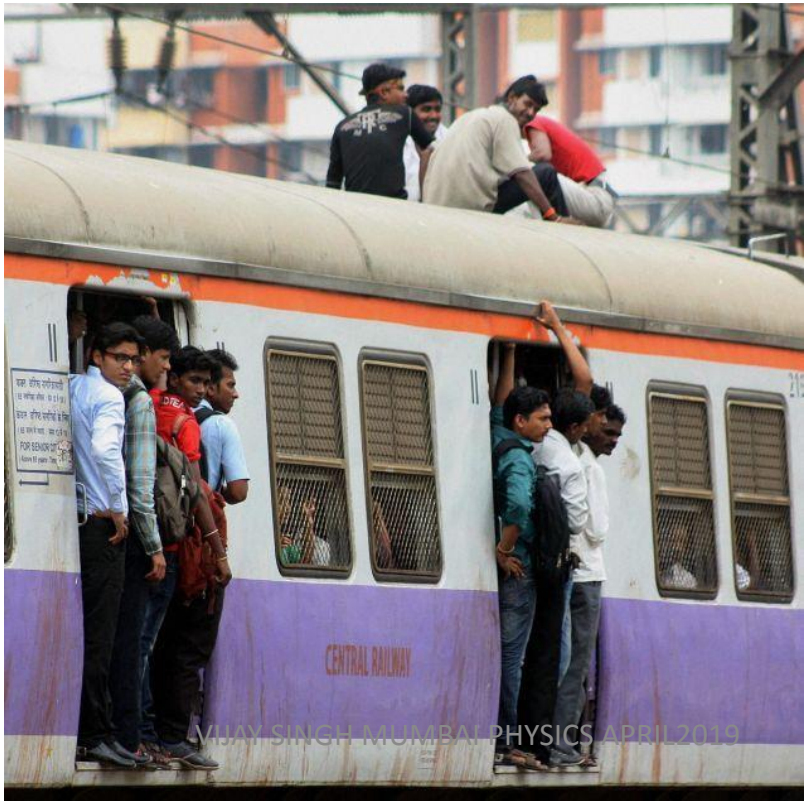
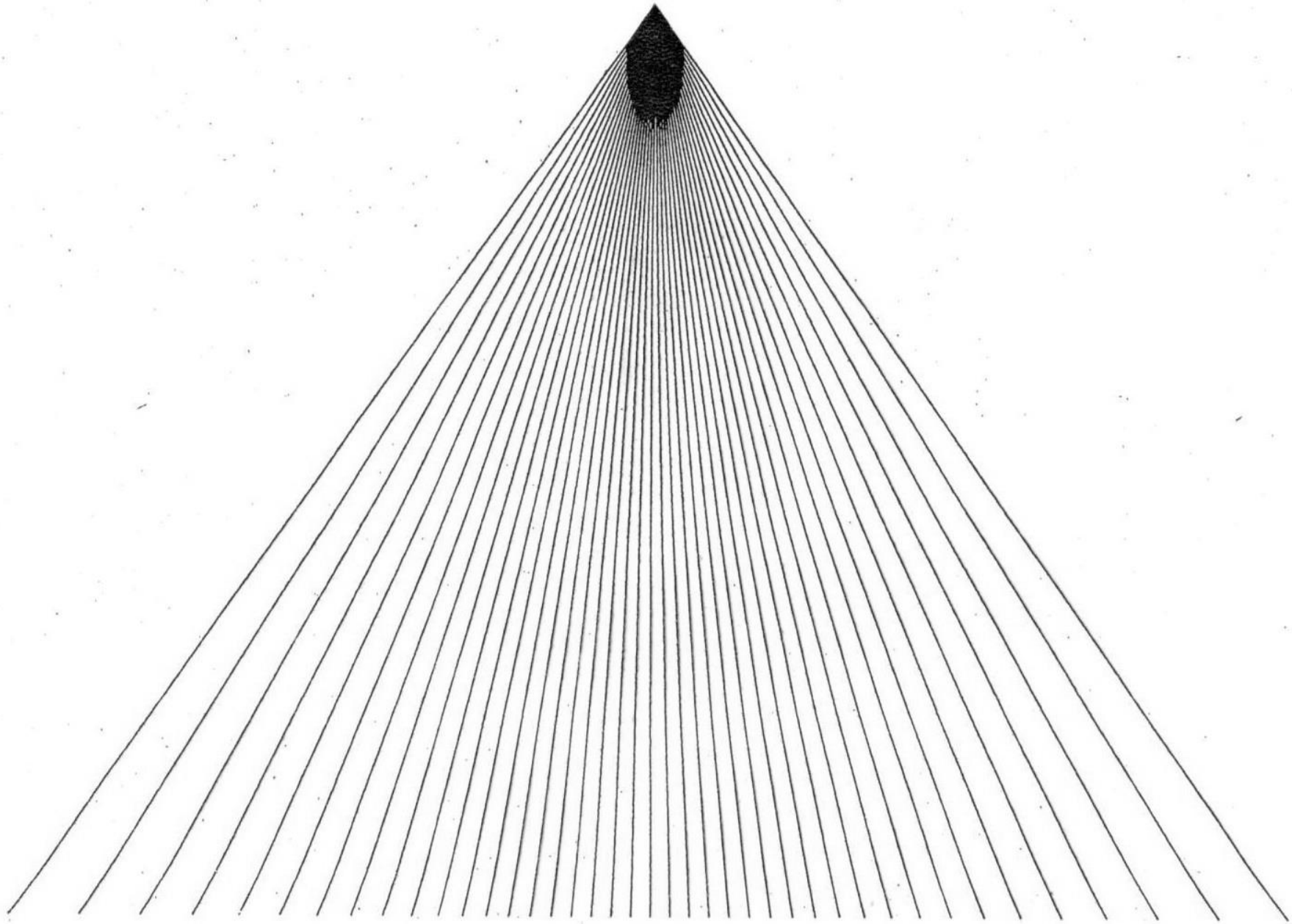
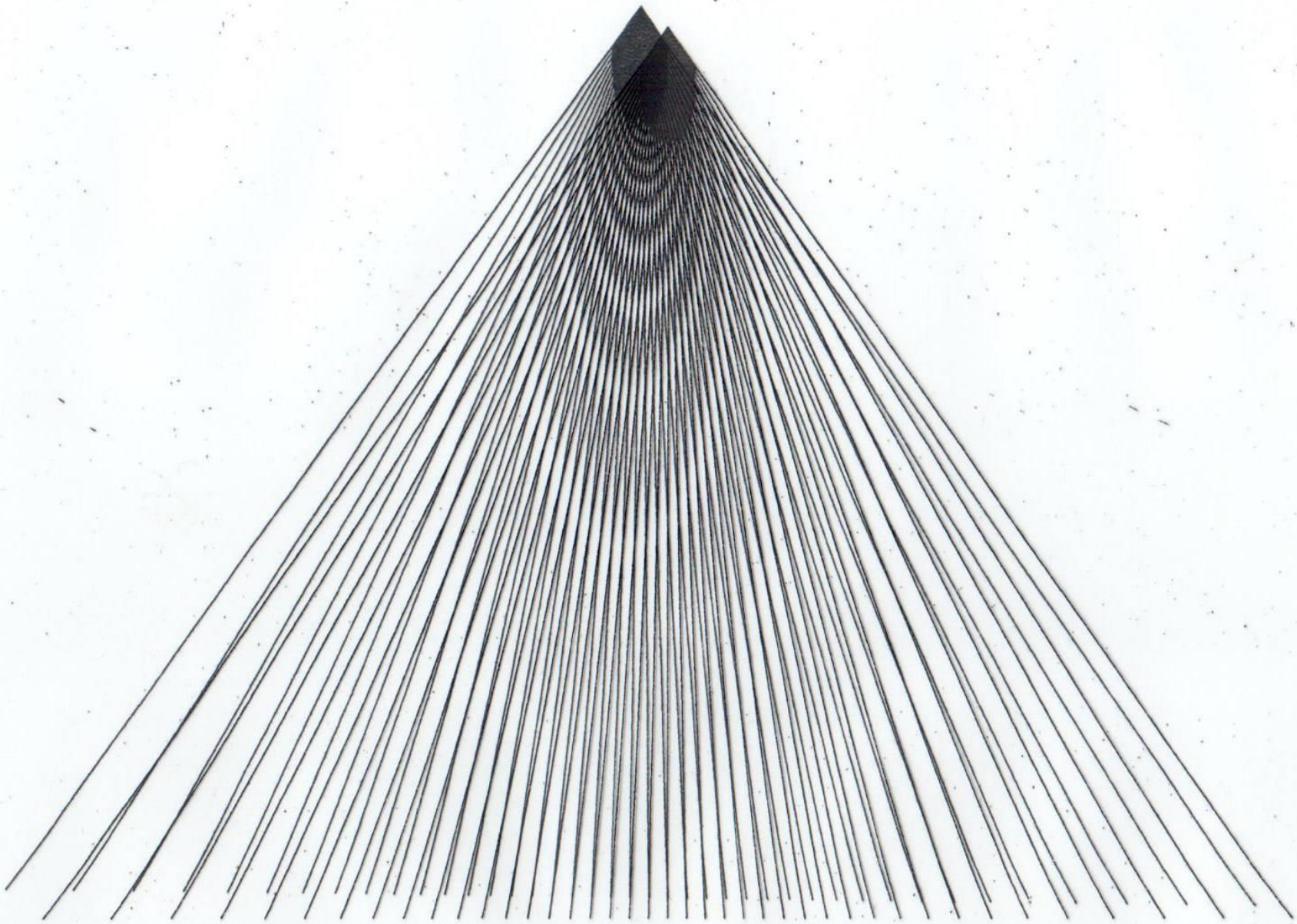

CENTRAL RAILWAY

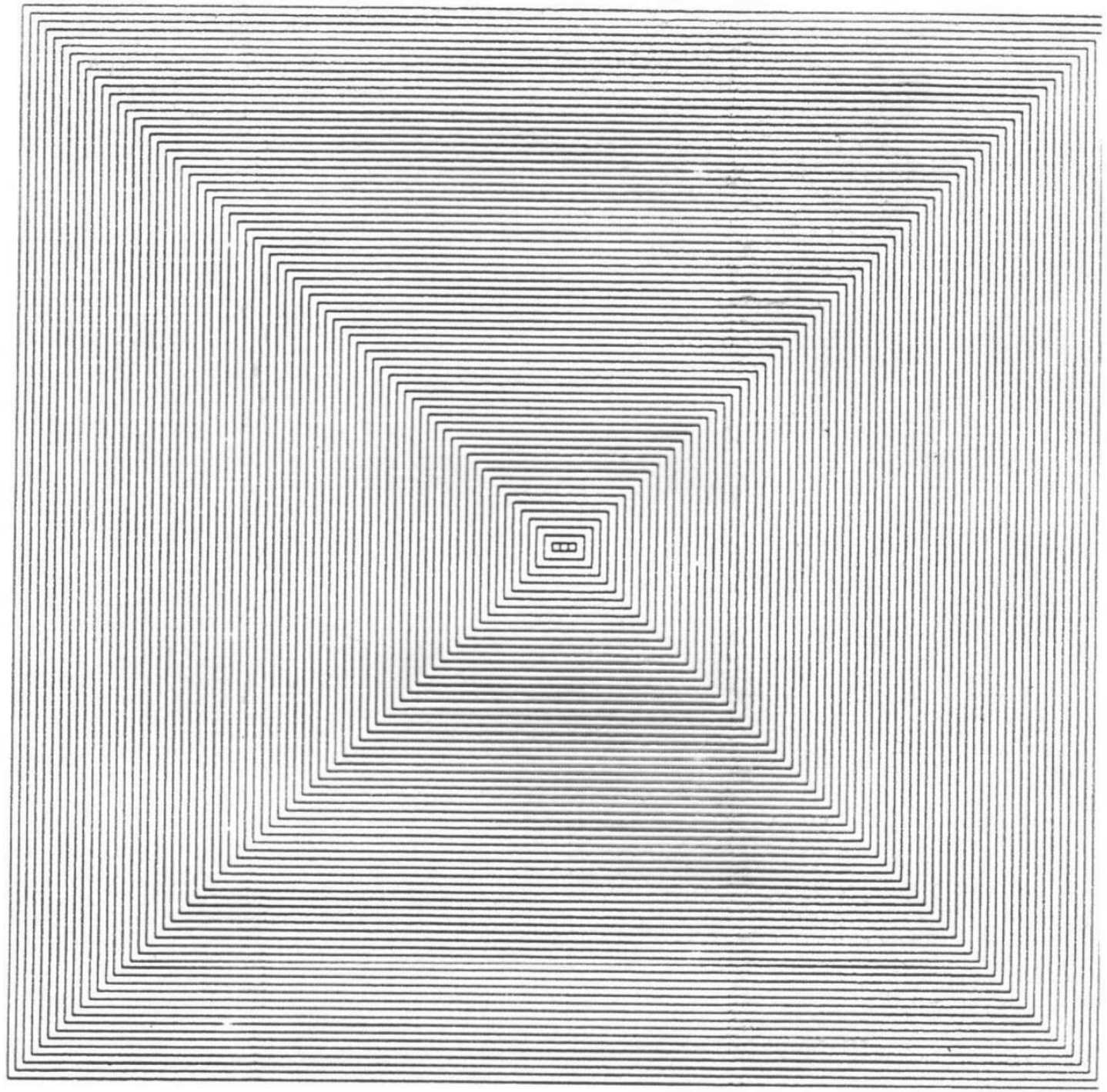
SEA-LINK

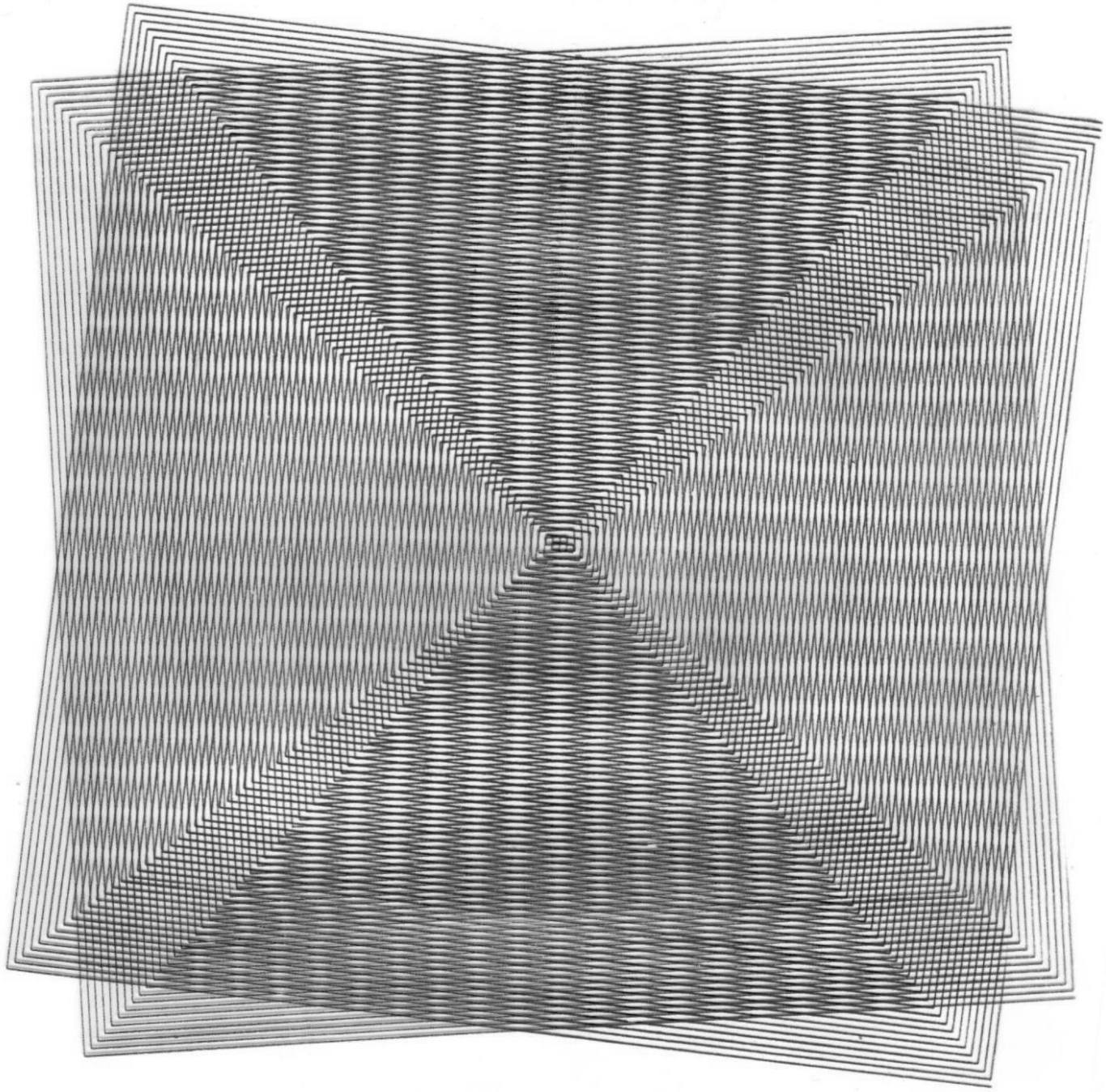
An Optical Phenomena





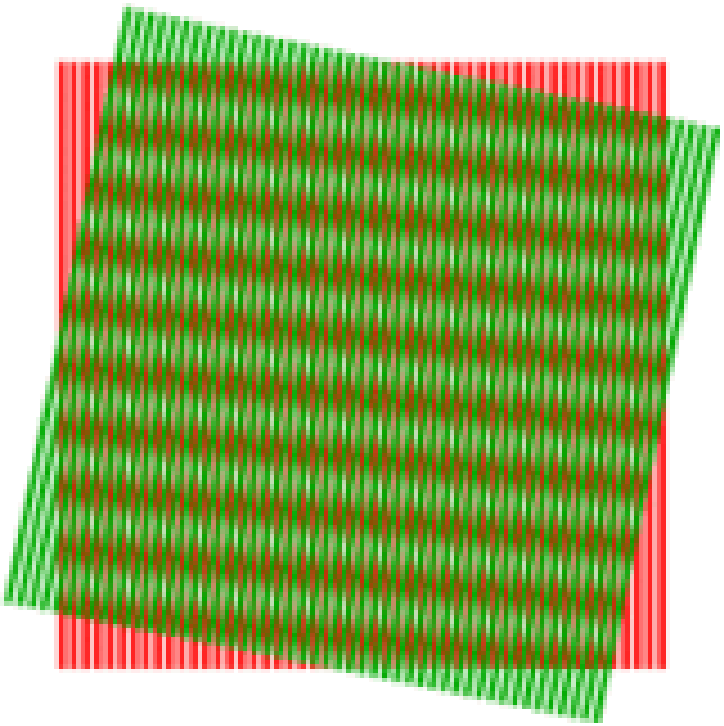
MOIRE PATTERNS

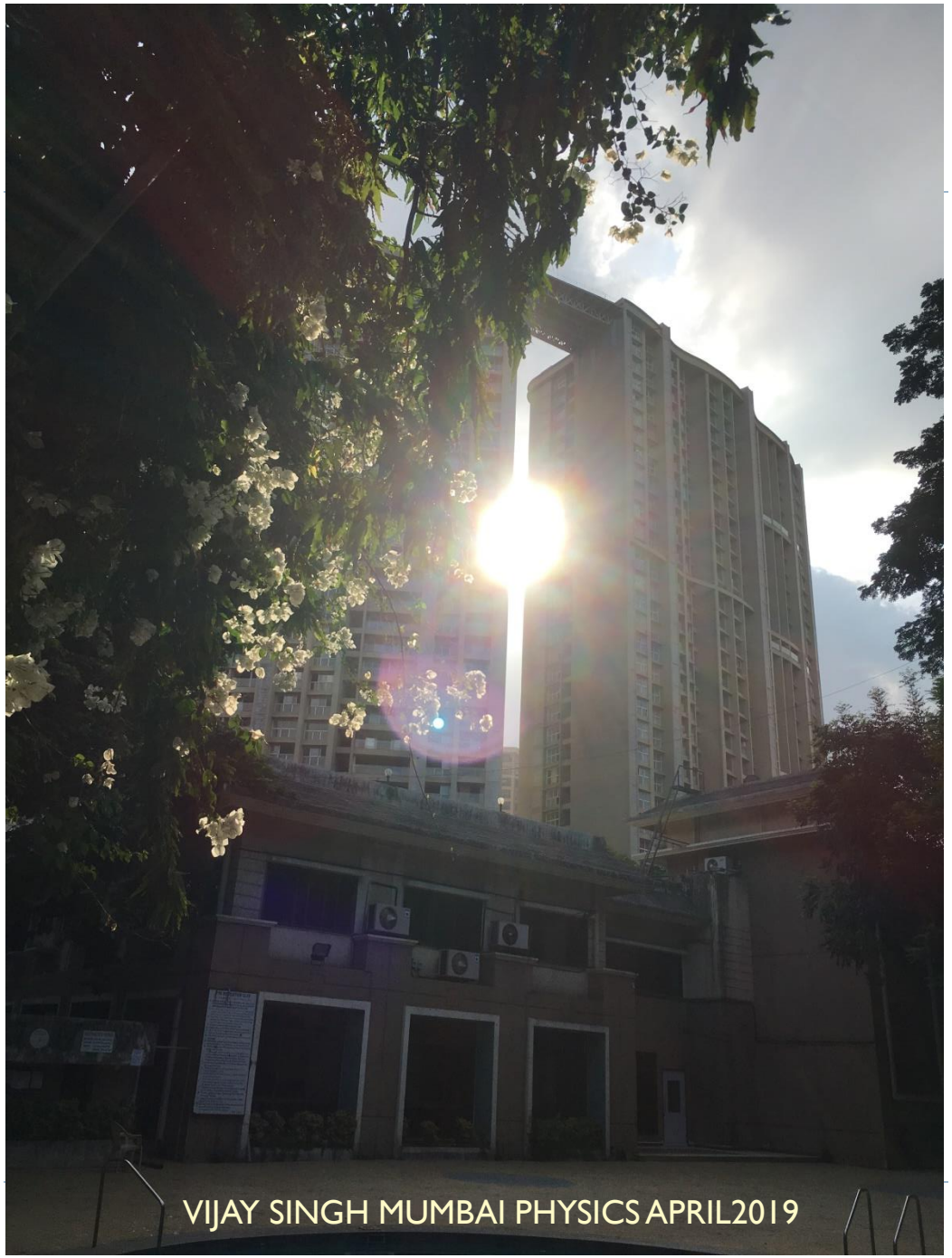




Use of Moire Pattern:

To detect minute imperfections

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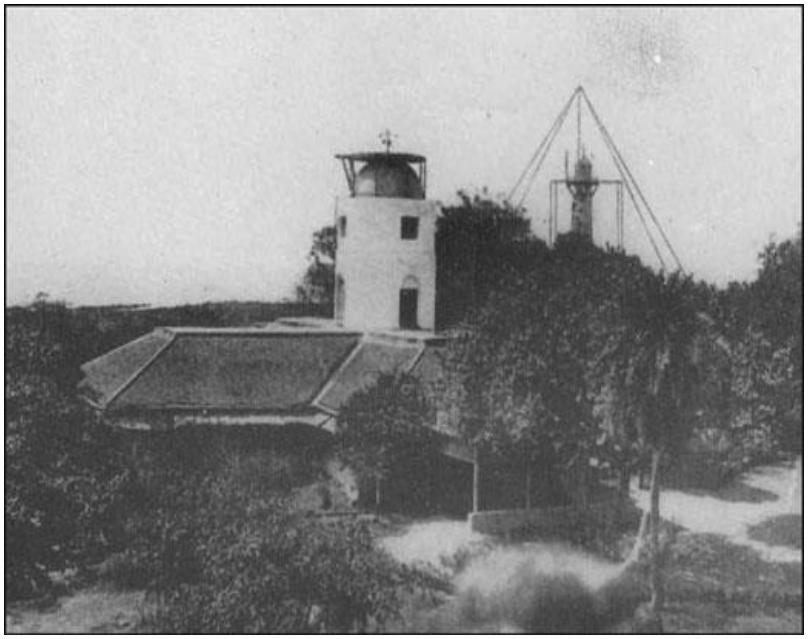
Bombay is associated with many great institutions

…*we look at one of the oldest*

Colaba Observatory

Built in 1826



TRAMS

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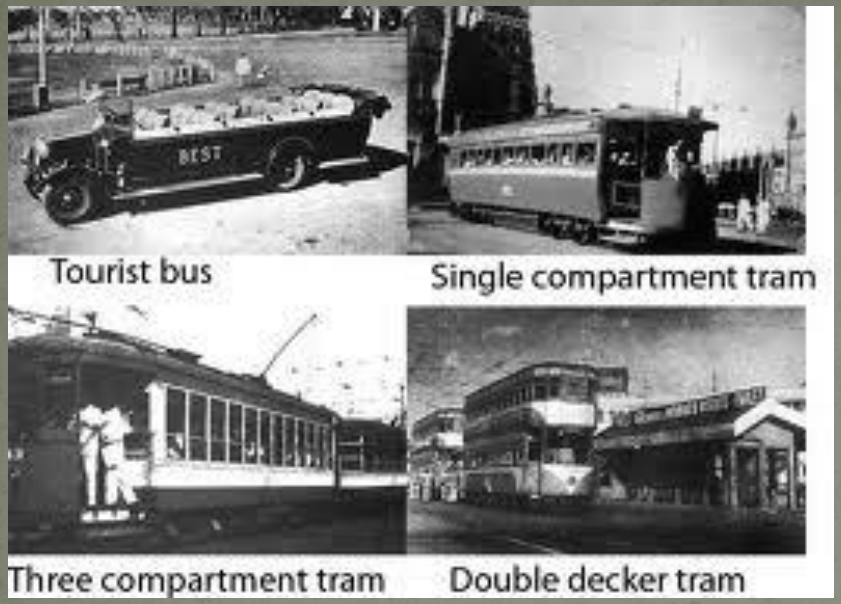

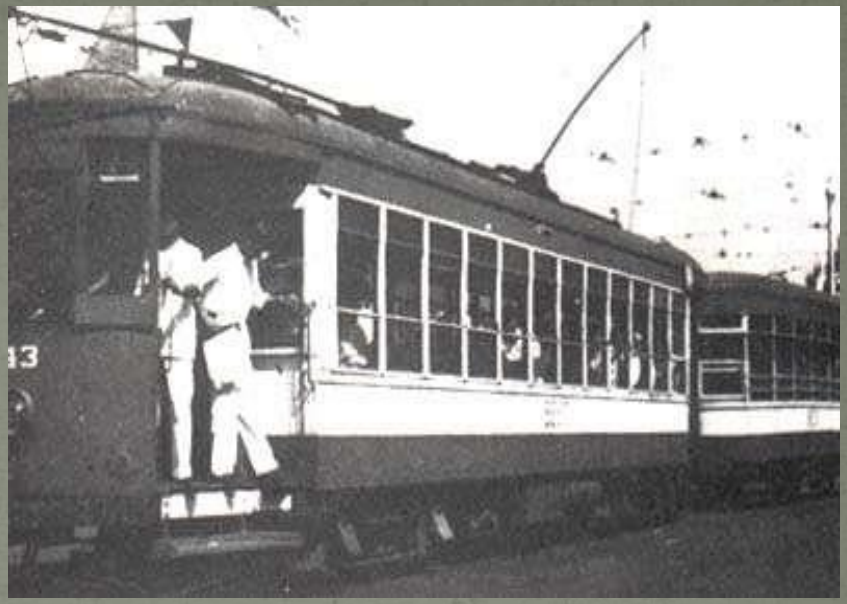

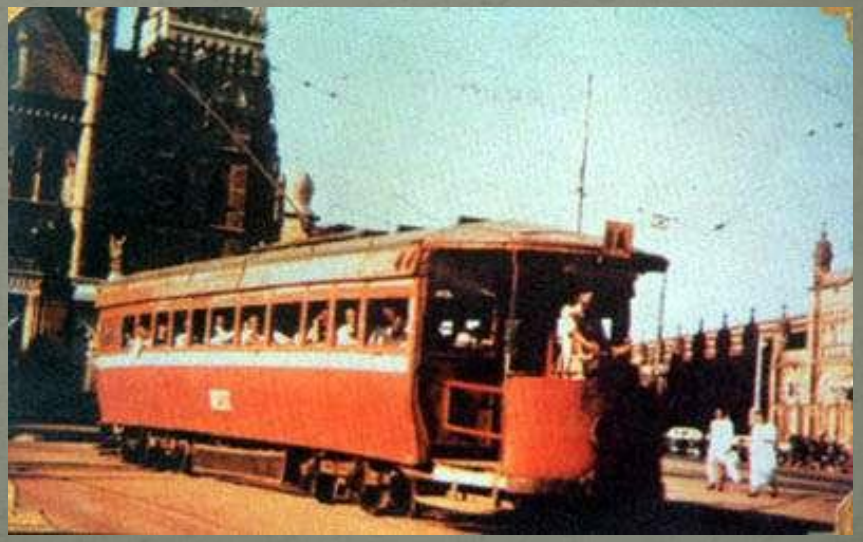

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DID YOU KNOW ?

- The **British introduced trams** in Mumbai during **1864-1873**
- First tram begun between **Parel** and **Colaba** on **9 May 1874**
- It was drawn by **6** to **8 horses**
- **Electrified** tram service was proposed in **1900**.

  But objections delayed them till **1907. *What were the objections?***
- **Double-deck** tram service began in **September 1920**
- Tram service closed on **31 March 1964**

And… there was a clash between these two institutions !

- The electric tram would cause **electromagnetic noise**. This noise would interfere with geo-magnetic recording.
- How ? We learn from Ampere's Law (1826).

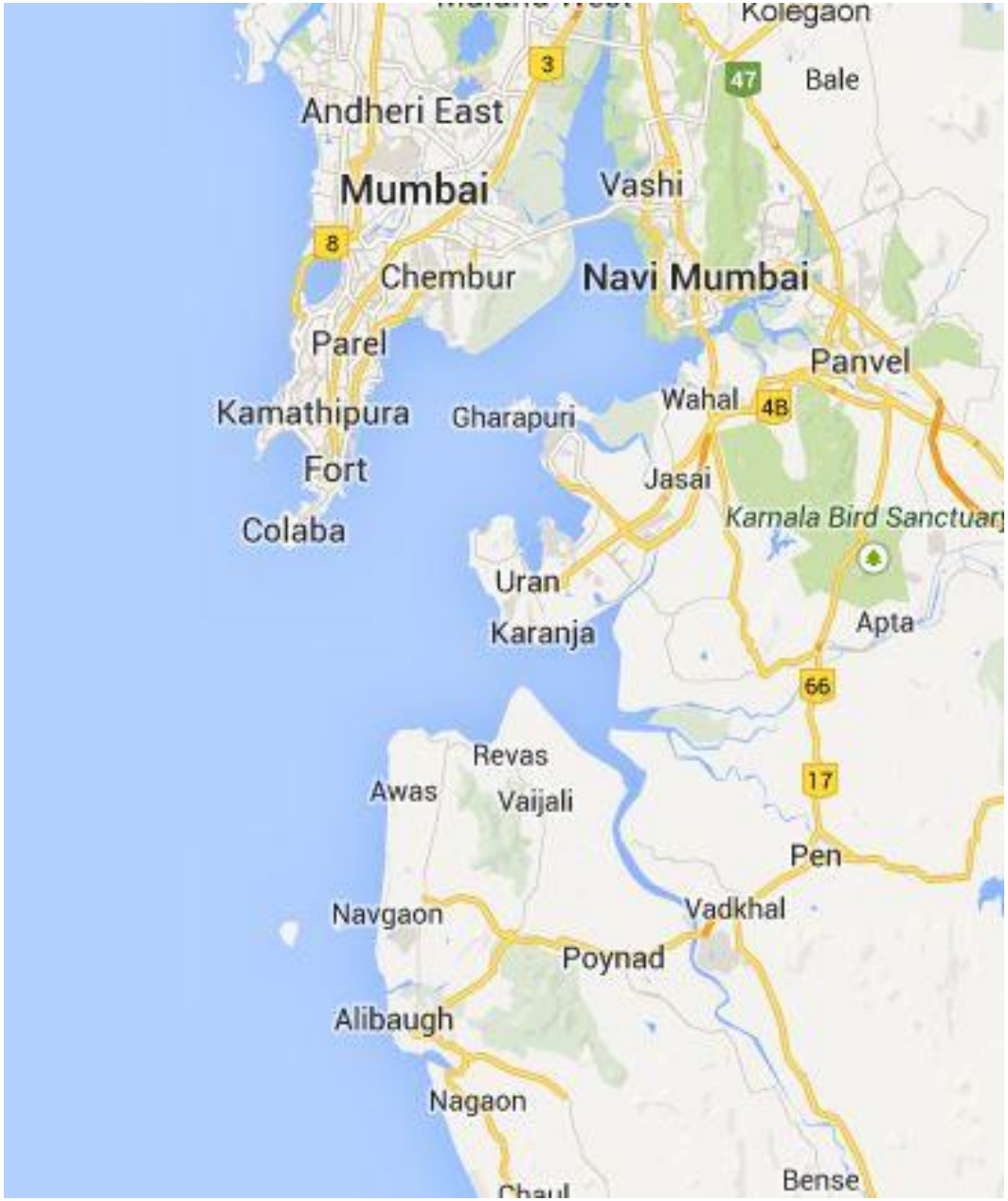
  Current = 20 Ampere

$$B(r) = \frac{\mu}{2\pi}\frac{I}{r} = 2\times10^{-7}\times\frac{I}{r} = \frac{2\times10^{-7}\times20}{100} = 4\times10^{-8}T = 0.0004G$$

$$\text{Magnetic Field of Earth at Mumbai} = 3.1000G$$

  Therefore, noise = ± 0.0004 G

- And hence, trams were not allowed in the Colaba region until the observatory shifted to Alibag.


Kolegaon
3
47
Bale
Andheri East
Mumbai
Vashi
8
Chembur
Navi Mumbai
Parel
Panvel
Kamathipura
Gharapuri
Wahal
4B
Fort
Jasai
Colaba
Karnala Bird Sanctuary
Uran
Karanja
Apta
66
Revas
Awas
Vaijali
17
Pen
Navgaon
Vadkhal
Poynad
Alibaugh
Nagaon
Bense

Magnetic observatory,
Alibaug

Bombay Natural History Society (BNHS) - 1883

Institutions in Mumbai

Veermata Jijabai Technological Institute (VJTI)

1887

Haffkine Institute 1899

Institutions in Mumbai

Tata Memorial Centre

1941

Institute of Science

Formerly known as the Royal Institute of Science

1920

Institutions in Mumbai

Tata Institute of Fundamental Research (TIFR)

Founded on 1st June 1945

Bhabha Atomic Research Centre (BARC)

Founded on 3st January 1954

Institutions in Mumbai

Indian Institute of Technology – Bombay
(IIT – B)

1958

GII – Gemmological Institute of India

Educational Services (1971)

- GII is the **FIRST** & India's **Longest** established provider of gem education to **International Standards.**

- **Their education standards are aligned to industry expectations**

- **Their** students are prepared to succeed in the highly competitive global economy and society

Indian Women Scientists' Association (IWSA) [1973]

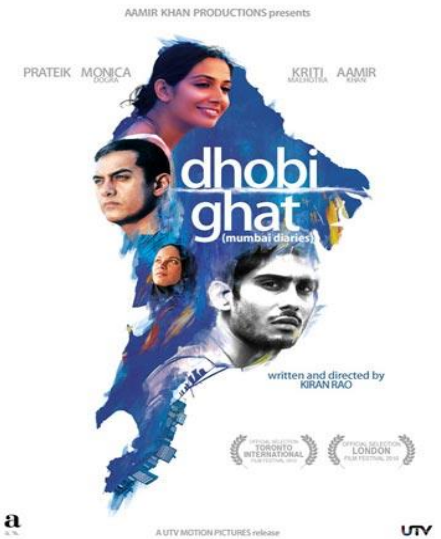
Dr. Bhau Daji Lad Museum (1855)

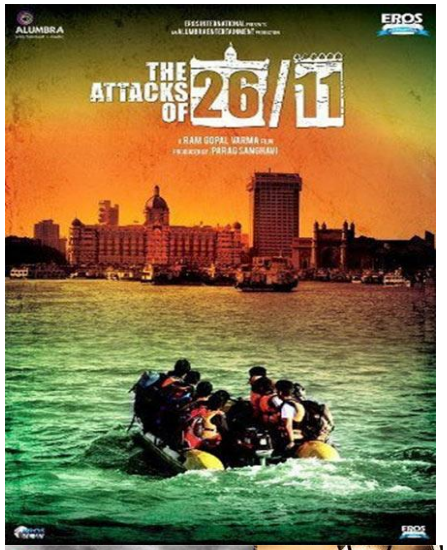
Chhatrapati Shivaji Maharaj Vastu Sangrahalaya (1922) [Prince of Wales Museum]

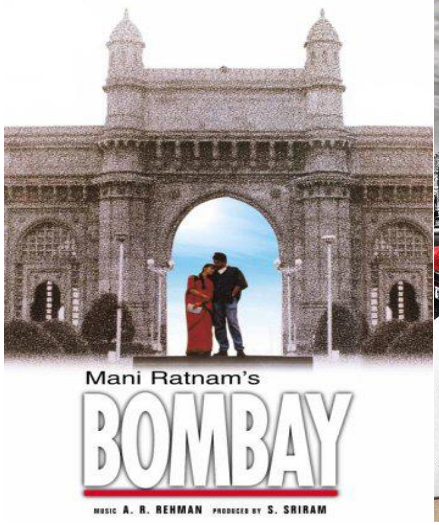
Nehru Planetarium (1977)

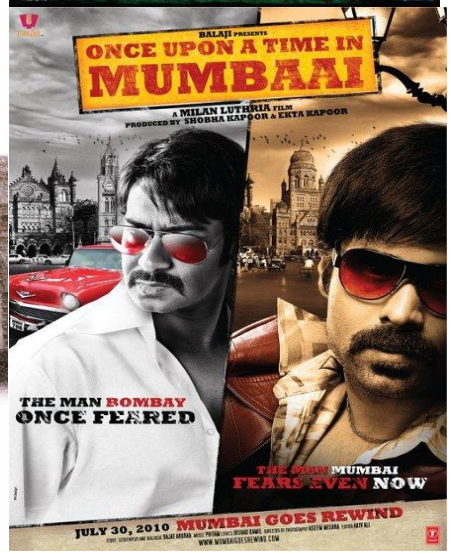
Nehru Science Centre (1985)

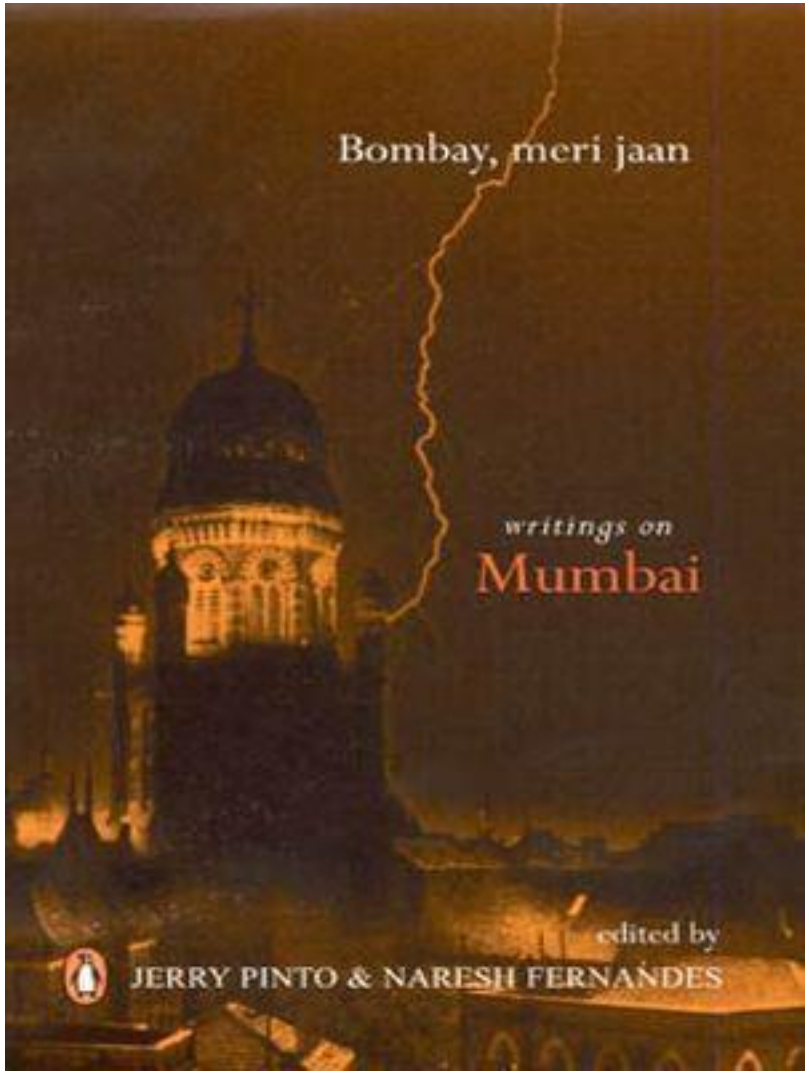
Bombay and Bollywood











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APRIL2019

Shimmering Moonlight

The Romance and Physics of Shimmering Moonlight

Reflection Width:

$$AB = \frac{h \sin(4\alpha)}{\sin^2\theta - \sin^2(2\alpha)}$$

Now α is small - 5° to 10°

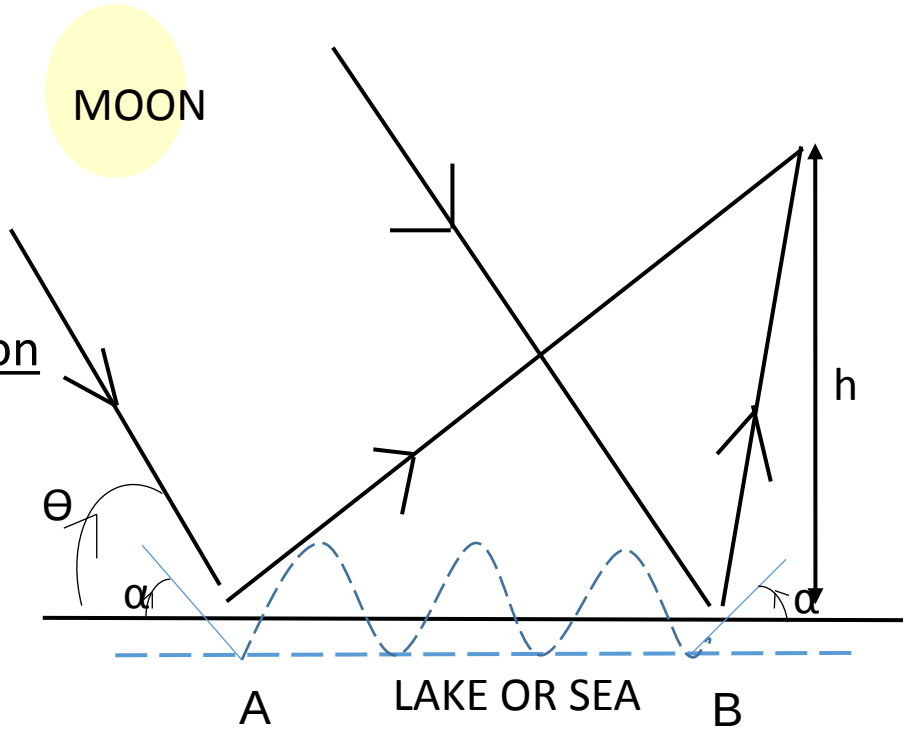
If source (moon) is close to horizon then …long reflection

Often,

$$AB \cong \frac{4h\alpha}{\sin^2\theta}$$

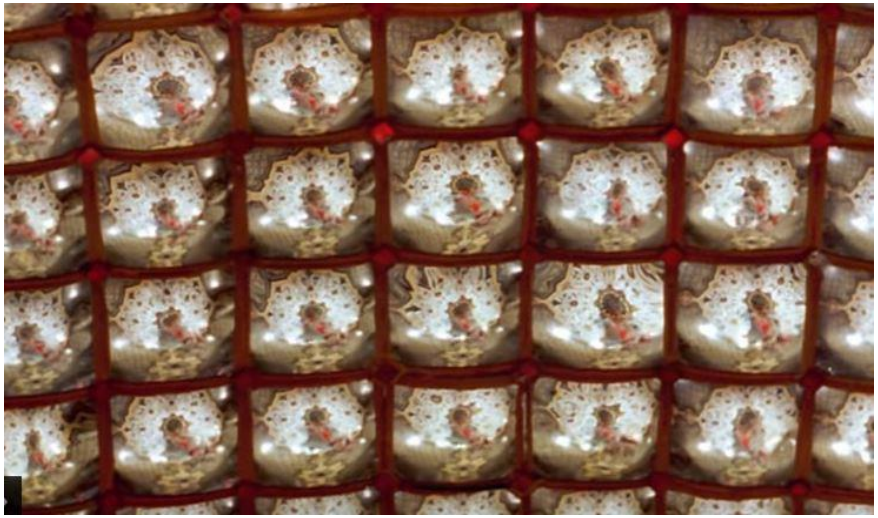
$$\cong 3 - 4 \text{ m}$$

$$(h = 2\text{m}, \theta = 30°)$$



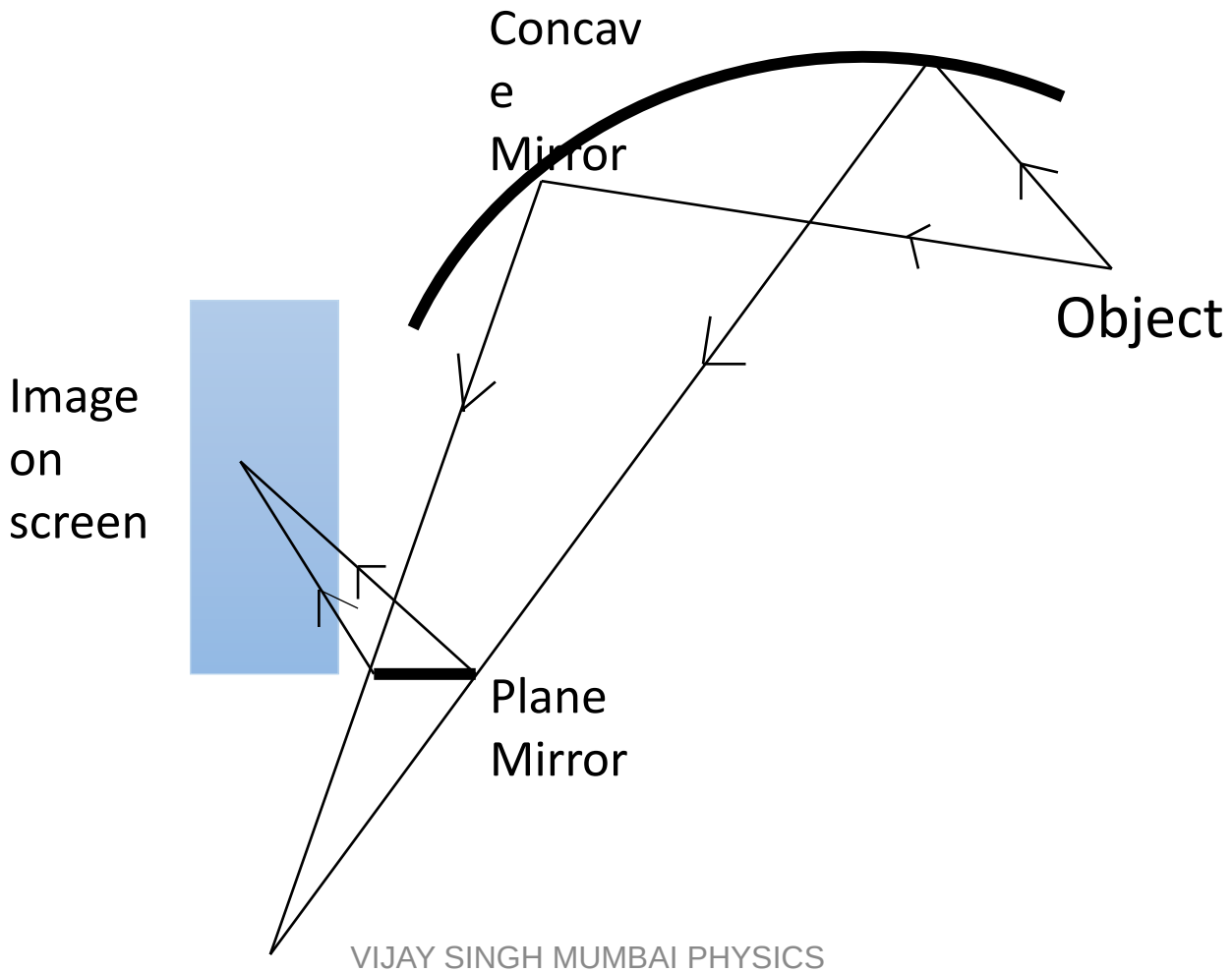
SHEMAROO

Mughal-e-Azam – the Sheesh Mahal



Aaina Mahal – Bajirao Mastani

Aaina Mahal – Bajirao Mastani Scene



MYSTERY

MISSING MUMBAI'S MILESTONES

- These basalt stones, originally three or four feet tall, mark miles from St Thomas's Church (today St Thomas's Cathedral) which, in the eighteenth century, comprised the city-centre.
- It cites inscription, location, landmark, date and remarks on the condition of each stone.
- Only six of 13 (or 15? Or 16?) stones mentioned, all Grade 1 heritage structures, have been located. Some have allegedly been removed, submerged or demolished by none other than road labourers hired by the BMC itself.

INSCRIPTION: 1 Mile From St Thomas's Church
LOCATION: Kalbadevi Road, in front of Navlakhi
Date: 1816-37

INSCRIPTION: 3 Miles From St Thomas's Cathedral
LOCATION: August Kranti Marg, in front of Central Bank, Gowalia Tank Branch
DATE: After 1837

INSCRIPTION: 3Miles From St Thomas's Church
LOCATION: Javji Dadaji Marg, opposite BHATIA HOSPITAL
DATE: 1816-37

MYSTERY

J. J. WATERSTONE: WHERE IN MUMBAI WAS HE I843?

J J **WATERSTONE**

LORD RAYLEIGH

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THANKS TO
MUMBAI
&
MUMBAIKARS
&
TO ALL OF YOU!