# PACE-IIT & MEDICAL

## (SOLUTION)

## Physics

1. Soln.: (1)

Total mass is $M_{total} = 2m + m = 3m$

The applied horizontal force is $F = kt$ According to Newton's second law (F = ma)

$$a = \frac{F}{M_{total}} = \frac{kt}{3m}$$

Now, isolate the block of mass m. The only horizontal force acting on this block is the contact force, N exerted by the block of mass 2m. Using Newton's second law for the mass m with the common acceleration a ;

$N = m \times a$

Substitute the expression for acceleration found in $N = m \times \left(\frac{kt}{3m}\right)$

$$N = \frac{kt}{3}$$

2. Soln.: (2)

$(M + m)g(\tan\theta + \mu)$

$ma\cos(\theta) - mg\sin(\theta) = 0$

Solving for the required acceleration a : $a = g\frac{\sin(\theta)}{\cos(\theta)} = g\tan(\theta)$

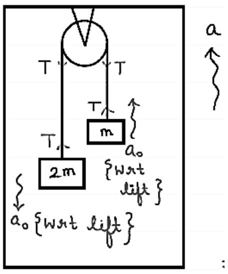
$F - f = (M + m)a$

$F = (M + m)a + f$

Substitute the values for a and f : $F = (M + m)g\tan(\theta) + \mu(M + m)g$

The minimum value of the force F is $F = (M + m)g(\tan(\theta) + \mu)$

3. Soln.: (1)




$2mg + 2\,ma - T = 2ma_0$

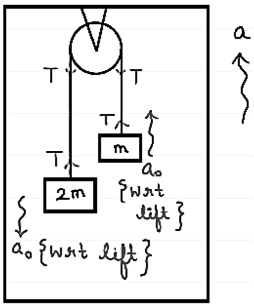
$T = mg - ma = ma_0$

$\Rightarrow 2mg + 2ma - T = 2T - 2mg - 2ma$

$\Rightarrow 4mg + 4ma = 3T$

$\Rightarrow T = \frac{4}{3}m(g + a)$

4. Soln.: (1)




$2mg + 2ma - T = 2ma_0$

$T - mg - ma = ma_0$

$mg + ma = 3ma_0$

$$\boxed{a_0 = (g + a)/3}$$

5. Soln.: (4)

$T = (m_1 + m_2)a_0$

$m_3g - T = m_3a_0$

$m_3g - (m_1 + m_2 + m_3)a_0$ .......(1)

Also, $N = m_1a_0$ & $m_1g = \mu N = \mu m_1 a_0$

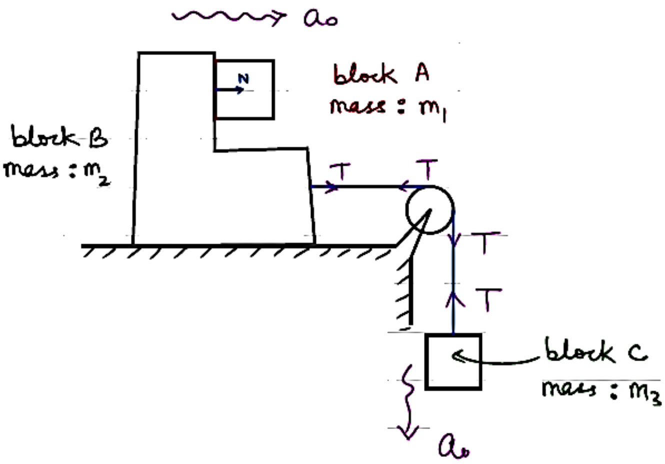
$\Rightarrow g = \mu a_0$

$\Rightarrow a_0 = g/\mu$

$\Rightarrow m_3 g = (m_1 + m_2 + m_3) \frac{g}{\mu}$ (from equation (1))

$\Rightarrow m_3(\mu - 1) = m_2 + m_1$

$\Rightarrow m_3 = \frac{m_2 + m_1}{(\mu - 1)}$




6. Soln.: (4)

- Work Done Definition: Work (W) performed by a force is defined as the dot product of the force vector $(\vec{F})$ and the displacement vector of its point of application $(\vec{d})$, given by the formula $W = \vec{F} \cdot \vec{d}$
- Static Friction Point of Application: The problem states there is no slipping between the foot and the ground. This means that for the entire 0.5 seconds the foot is in contact with the ground (the stance phase), the specific point where the static friction force is applied is momentarily stationary relative to the ground. The displacement of the point of application $(\vec{d})$ is 0 meters.
- Calculation: Because the displacement of the point of application is zero, the work done by the static friction force is zero, regardless of the magnitude of the force (120 N) or the time it acts $W = 120N \times 0\,m = 0J$.

7. Soln.: (3)

- Mass of the particle , m = 4 kg
- Assumed initial velocity $v_i = 2m/s$
- Assumed final velocity $v_f = 4m/s$

The work done (W) by the single force on the particle is equal to the change in its kinetic energy $(\Delta K)$ The formula for kinetic energy is $K = \frac{1}{2}mv^2$

The change in kinetic energy is calculated as: $W = \Delta K = k_f - k_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

Substitute the given values into the equation:

$W = \frac{1}{2} \times 4kg \times ((4m/s)^2 - (2m/s)^2)$

$$W = 2kg \times (16m^2/s^2 - 4m^2/s^2)$$
$$W = 2kg \times (12m^2/s^2)$$
$$W = 24\ J$$

8. Soln.: (1)

The given values are the spring constant k = 400 N/m , initial compression $x_i = -5cm = -0.05m$ and final extension $x_f = 10cm = 0.10m$

$$U = \frac{1}{2}kx^2$$

The initial potential energy $U_i$ is calculated as

$$U_i = \frac{1}{2}kx_i^2 = \frac{1}{2}(400N/m)(-0.05m)^2 = 200 \times 0.0025J = 0.5J$$

The final potential energy $U_f$ is calculated as

$$U_f = \frac{1}{2}kx_f^2 = \frac{1}{2}(400N/m)(0.10m)^2 = 200 \times 0.01J = 2.0J$$

The work done by the external force is equal to the change in potential energy

$$\Delta U_s = U_f - U_i$$
$$W_{ext} = U_f - U_i = 2.0J - 0.5J = 1.5J$$

9. Soln.: (2)

- Power (P) is defined as the rate at which is done, or the force multiplied by velocity P = $F\nu$
- The particle starts from rest, and the power P is constant.
- Force (F) can be expressed as mass times acceleration (F = ma) and acceleration (a) is the rate of change of velocity $\left(\frac{d\nu}{dt}\right): F = m\frac{d\nu}{dt}$
- Substituting this into the power equation: $P = \left(m\frac{d\nu}{dt}\right)\nu$
- Rearranging and integrating with respect to time (from $t = 0$ , $\nu = 0$ )

$$Pdt = m\nu\, d\nu$$
$$\int_0^t Pdt = \int_0^\nu m\nu\, d\nu$$
$$Pt = \frac{1}{2}m\nu^2$$
$$\nu^2 = \frac{2Pt}{m}$$
$$\nu = \sqrt{\frac{2P}{m}} \cdot t^{1/2}$$

- Velocity (v) is the rate of change of distance $\left(\frac{dx}{dt}\right): \nu = \frac{dx}{dt}$
- Substituting the expression for $\nu$ and integrating with respect to time(from t = 0, x = 0 )

$$\frac{dx}{dt} = \sqrt{\frac{2P}{m}} \cdot t^{1/2}$$
$$dx = \sqrt{\frac{2P}{m}} \cdot t^{1/2}dt$$

$$\int_0^x dx = \int_0^t \sqrt{\frac{2P}{m}} \cdot t^{1/2} dt$$

$$x = \sqrt{\frac{2P}{m}} \cdot \left[\frac{t^{3/2}}{3/2}\right]_0^t$$

$$x = \sqrt{\frac{2P}{m}} \cdot \frac{2}{3} \cdot t^{3/2}$$

$$x = \frac{2}{3}\sqrt{\frac{2P}{m}} \cdot t^{3/2}$$

This shows that the distance x is proportional to $t^{3/2}$ or $x \propto t^{3/2}$. The correct option would be the one that matches this relationship

10. Soln.: (3)

Given power delivered is constant P

$$P = F\nu = \frac{d}{dt}\left(\frac{1}{2}m\nu^2\right) = m\nu\frac{d\nu}{dt}$$

So, $m\nu\frac{d\nu}{dt} = P$

But $\frac{d\nu}{dt} = \nu\frac{d\nu}{dx}$. Hence,

$$m\nu \cdot \nu\frac{d\nu}{dx} = P$$

$$m\nu^2\frac{d\nu}{dx} = P$$

$$\nu^2 d\nu = \frac{P}{m}dx$$

Integrate from rest ($\nu = 0$ at x = 0)

$$\frac{\nu^3}{3} = \frac{P}{m}x$$

$$\nu = \left(\frac{3P}{m}x\right)^{1/3}$$

$$\nu \propto x^{1/3}$$

11. Soln.: (2)

We know

$\mu_2 \sin\theta_2 = \mu_1 \sin\theta_1$

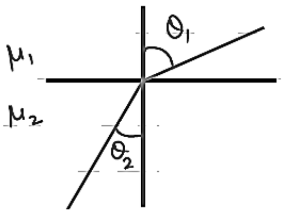
Note that in our question

$\theta_1 = 90^o \Rightarrow \sin\theta_1 = 1$

& $\sin\theta_2 = \cos\alpha$ (from figure)

$\therefore \mu_2 \cos\alpha = \mu_1$

$$\alpha = \cos^{-1}\left(\frac{\mu_1}{\mu_2}\right)$$



12. Soln.: (4)

Object moves along principal axis toward a concave mirror with speed

$u_0 = 2\text{m s}^{-1}$

At that instant u = 20 cm , *f* = 15 cm

Using sign convention:

u = – 20 cm, f = – 15 m

Mirror formula

$$\frac{1}{f}=\frac{1}{v}+\frac{1}{u}\Rightarrow\frac{1}{-15}=\frac{1}{v}+\frac{1}{-20}$$

$$\Rightarrow \frac{1}{v}=-\frac{1}{60}\Rightarrow v=-60\text{cm}$$

Differentiate

$$0=-\frac{1}{v^2}\frac{dv}{dt}-\frac{1}{\mu^2}\frac{du}{dt}\Rightarrow\frac{dv}{dt}=-\frac{v^2}{u^2}\frac{du}{dt}$$

So speeds

$$v_i=\frac{v^2}{u^2}v_o=\frac{60^2}{20^2}\times 2=9\times 2=18\text{m s}^{-1}$$

13. Soln.: (3)

Object at same position ( $u=-20\text{ cm}$ ) moves perpendicular to principal axis with speed $2\text{ms}^{-1}$

From above $v=-60$ cm

Linear magnification

$$m=-\frac{v}{u}=-\frac{-60}{-20}=-3\Rightarrow|m|=3$$

For transverse motion:

$$v_i=|m|v_o=3\times 2=6\text{ ms}^{-1}$$

14. Soln.: (2)

– 20 cm

We are given the focal length (*f*) of a convex mirror is 20 cm , which is positive by convention *f* = +20 cm . The image distance ( $v$ ) is 10 cm behind the mirror, which is also positive by convention: $v+10\text{cm}$ . The object distance (u) needs to be found

The mirror formula relates the bject distance (u) image distance ( $v$ ) and focal length (f)

$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$$

We rearrange the formula to solve for the object distance

$$\frac{1}{u}=\frac{1}{f}-\frac{1}{v}$$

Substitute the given values into the rearranged formula

$$\frac{1}{u}=\frac{1}{+20\text{cm}}-\frac{1}{+10\text{cm}}$$

$$\frac{1}{u}=\frac{1-2}{20\text{cm}}$$

$$\frac{1}{u}=\frac{-1}{20\text{cm}}$$

Inverting this gives the object distance

U = – 20 cm

15. Soln.: (3)

Note: $\delta = 180 - 2\overset{0}{L}$ (formula)

Here $\overset{0}{L} = 90 - \alpha$

$\therefore\ \delta = 180 - 2(90 - \alpha) = 2\alpha$

## Chemistry

16. Soln.: (1)
Z = 35 (Br) → 2,8,18,7; four shells → period 4; seven valence electrons → group 17 (halogens).

17. Soln.: (3)
$Al_2O_3$ reacts with both acids and bases, so aluminium oxide is amphoteric.

18. Soln.: (3)
X (2,8,2) → $X^{2+}$; Y (2,8,7) → $Y^{-}$; charge balance gives $XY_2$ (like $MgCl_2$).

19. Soln.: (1)
Non-metallic character increases left to right; sequence Na to S in period 3 follows this trend.

20. Soln.: (1)
In a period, radius decreases left to right; Li is the left-most element in period 2 among these, so it is largest.

21. Soln.: (2)
Mixing $AgNO_3$ and NaCl forms insoluble AgCl as a white precipitate (double displacement).

22. Soln.: (2)
$2Pb(NO_3)_2$ → 2PbO (yellow) + $4NO_2$ (brown fumes) + $O_2$; $NO_2$ is brown and residue PbO is yellow

23. Soln.: (3)
$Cu^{2+}$ in CuO is reduced to Cu(0); $H_2$ (0) is oxidised to $H^{+}$ in water; hence redox.

24. Soln.: (3)
Rust is mainly hydrated iron(III) oxide formed when iron reacts with oxygen and moisture; this slow surface attack is corrosion.

25. Soln.: (2)
Cl− in HCl goes from −1 to 0 in $Cl_2$ (loss of electrons = oxidation); $Mn^{4+}$ → $Mn^{2+}$ is reduction.

26. Soln.: (2)
Heating silver nitrate breaks it into Ag, $NO_2$ and $O_2$; a single compound decomposes into simpler substances due to heat.

27. Soln.: (2)
$BaCl_2$ + $H_2SO_4$ → $BaSO_4$ (white ppt) + 2HCl; $BaSO_4$ is insoluble white solid.

28. Soln.: (2)
$Cl_2$ displaces Br from KBr to form KCl and $Br_2$ a more reactive halogen displaces a less reactive one

29. Soln.: (3)

$Cl_2$ gains electrons (0 → −1 in $Cl^-$), so it is reduced and acts as oxidising agent, causing $I^-$ to oxidise to $I_2$

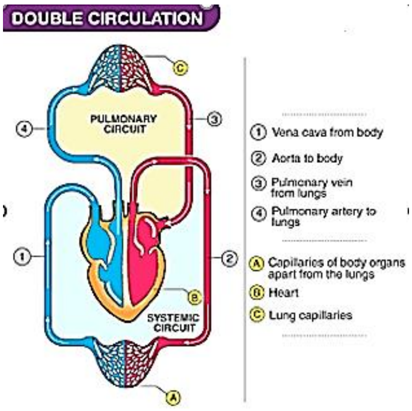
30. Soln.: (4)

Balance C: $C_3H_8 \rightarrow 3CO_2$ (so coefficient 3); balance H: $8H \rightarrow 4H_2O$; O on RHS = 3×2 + 4 = 10; need $5O_2$, but to avoid fraction multiply all by 2: $2C_3H_8 + 7O_2 \rightarrow 6CO_2 + 8H_2O$, so coefficients 2,7,6,8 (option D).

# Biology

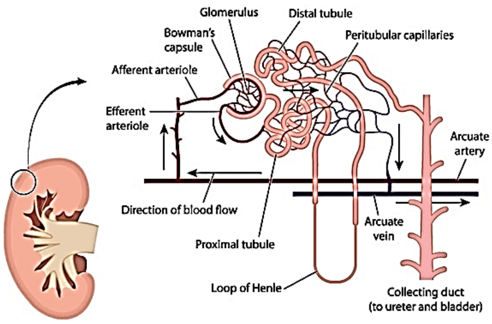
31. Soln.: (2)

The oxygenated blood is carried from the lungs to the left auricle (atrium) by the (2) **Pulmonary vein,** which are unique veins that transport oxygen-rich blood back to the heart, unlike other veins that carry deoxygenated blood. Pulmonary Vein: Carries oxygenated blood from the lungs to the left atrium




32. Soln.: (3)

Ultrafiltration, the initial filtering of blood to form urine, occurs in the **(3) Bowman's capsule,** specifically where the glomerulus (a network of capillaries) pushes fluid into the capsular space, with the capsule's unique podocyte cells forming filtration slits. The other parts (PCT, Loop of Henle, Collecting Duct) handle reabsorption and secretion, not initial filtration.




33. Soln.: (2)

- Trypsin is an enzyme that helps digest proteins in the small intestine.
- It is produced by the **pancreas** and secreted as an inactive precursor called **trypsinogen.**
- This ensures that the enzyme does not digest the pancreas tissue itself.
- Trypsinogen is then activated into its functional form, trypsin, in the small intestine by the enzyme enteropeptidase.

34. Soln.: (1)

(i) **They help in emulsification of fats:** Bile salts act as detergents to break down large fat globules into smaller fat droplets, which significantly increases the surface area for the fat-digesting enzyme lipase to work more efficiently.

(ii) **They help in formation of micelles**: After emulsification and digestion into fatty acids and monoglycerides, bile salts help incorporate these components into tiny, water-soluble spheres called micelles, which are crucial for the absorption of fats and fat-soluble vitamins by the intestinal lining.

(iii) **They are present in alkaline medium**: Bile, which contains bile salts, is an alkaline fluid (hepatic bile has a pH of around 8.6, while in the gallbladder it is around 7.6 or 7.5). This alkaline nature is essential to neutralize the acidic chyme coming from the stomach, providing the optimal pH environment for intestinal and pancreatic enzymes (like lipase) to function in the small intestine.

35. Soln.: (2)

Capillaries are the smallest and thinnest blood vessels in the body. Their walls consist of only a single layer of endothelial cells and lack any muscular tissue. This unique structure facilitates the essential exchange of gases (oxygen and carbon dioxide), nutrients, and waste products between the blood and surrounding body tissues through diffusion.

36. Soln.: (2)

Tendons are a tough band of fibrous connective tissue that connects muscle to bone and is capable of withstanding tension to allow for movement.

37. Soln.: (1)

**Ciliary body**. More specifically, the ciliary muscles within the ciliary body change the shape of the eye lens to adjust its focal length, a process known as accommodation.

38. Soln.: (4)

Calcium ($Ca^{2+}$) levels in the blood are primarily controlled by the (4) Thyroid and parathyroid glands, with the parathyroid hormone (PTH) raising low levels and calcitonin (from the thyroid) lowering high levels, working together with Vitamin D for overall regulation, while the hypothalamus, FSH, and pancreas manage other functions like temperature, reproduction, and glucose, respectively

39. Soln.: (1)

Wings of a pigeon & a bat

40. Soln.: (4)

Diabetes mellitus (commonly known as diabetes) is a condition characterized by high blood sugar levels, which is caused by the body either not producing enough insulin or not using the **insulin** it produces effectively (insulin resistance). **Insulin** is a hormone secreted by the pancreas that helps transport glucose from the bloodstream into the body's cells to be used for energy.

41. Soln.: (1)

- Pteridophytes (ferns, horsetails, clubmosses) are known as vascular cryptogams because they possess vascular tissues (xylem and phloem) for the transport of water and nutrients, but they reproduce by means of spores rather than seeds or flowers.
- The term "cryptogam" means "hidden reproduction" (referring to reproduction via spores), and "vascular" indicates the presence of a vascular system.

42. Soln.: (3)

Color blindness is an X-linked recessive trait. We denote the normal allele as $X^C$ and the color-blind allele as $X^C$.

The man is color blind, so his genotype is $X^CY$ The woman is normal. Assuming she is homozygous normal (as is standard in such problems unless stated otherwise), her genotype is $X^CX^C$

We cross the parents $X^CY \times X^CX^C$

| **Gametes** | $X^C$ | $X^C$ |
|---|---|---|
| $X^C$ | $X^CX^c$ | $X^CX^c$ |
| Y | $X^CY$ | $X^CY$ |

All sons produced by this cross have the genotype $X^CY$ Since they possess the dominant normal allele $X^C$, none of them will be color blind. The probability is 0%.

The chance of their son to be colour blind is 0%

43. Soln.: (2)

In all known forms of DNA, including eukaryotic DNA, the rules of base pairing (Chargaff's rules) state that:

- **Adenine (A) always pairs with Thymine (T)** via two hydrogen bonds.
- **Guanine (G) always pairs with Cytosine (C)** via three hydrogen bonds.

This specific pairing ensures the consistent diameter of the DNA double helix and allows for accurate replication and transcription

44. Soln.: (2)

A plant's pollen grain is a male gamete and is therefore haploid (n), containing a single set of chromosomes. A leaf cell is a somatic, or vegetative, cell and is diploid (2n), meaning it contains two sets of chromosomes.

The diploid number (2n) is twice the haploid number

Given the number of chromosomes in the pollen grain (n) is 5.

The number of chromosomes in the leaf cell (2n) can be calculated using the formula $2n = 2 \times n$

Substituting the given value $2n = 2 \times 5$

Therefore 2n = 10

45. Soln.: (1)

The net ATP yield from one glucose molecule during anaerobic respiration is 2 ATP. This corresponds to option (1).

46. Soln.: (3)

During anaphase of mitosis (or anaphase II of meiosis), the centromere of each duplicated chromosome splits. This allows the sister chromatids to separate and move to opposite poles of the cell, becoming individual chromosomes in the process. This physical separation is crucial to ensure that each daughter cell receives an identical and complete set of chromosomes.

47. Soln.: (2)

Statement (2) is correct because oxysomes (also known as $F_0 - F_1$ particles) are indeed complex structures found in the inner mitochondrial membrane, which are involved in ATP synthesis and are composed of three distinct parts: a base $F_0$ subunit embedded in the membrane), a stalk, and a head $F_1$ subunit extending into the mitochondrial matrix).

48. Soln.: (1)

Axial flower position is a dominant trait in pea plants, meaning it expresses itself even if only one dominant allele is present.

49. Soln.: (4)
A group of sepals is called the Calyx, which is the outermost whorl of a flower, typically green and protective of the bud; while **petals** form the corolla, **stamens** form the androecium (male parts), and **carpels** form the gynoecium (female parts).

50. Soln.: (1)
Salivary amylase is also called Ptyalin