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Model Practice Paper — Engineering Mechanics

BTEUP Diploma • 1st Semester (First Year — Common Curriculum, All 41 Branches)

Session 2026-27

Practice Questions / Model Paper — NOT a BTEUP board paper

Time: 2.30 Hours

Max. Marks: 60

General Instructions:

- All questions are compulsory. Each question has three parts (a), (b) and (c) — **answer any two** of the three parts in every question.
- Each part carries 6 marks; each question carries 12 marks.
- Draw neat, labelled diagrams wherever they are asked or wherever they support your answer.
- Write your answers in your own words, in the same order as the questions.

About this paper: This is an original practice (model) paper prepared by KAMALDNP Academy from the official BTEUP 2026-27 syllabus topics for this subject. It is NOT a BTEUP board paper, and no question in it is promised to appear in your examination. Its structure follows the board's last published paper pattern (5 questions, each with three parts of which any two are to be answered), scaled to this subject's theory maximum of 60 marks (external) in the verified 2026-27 scheme; the printed time follows the same last published pattern. The 2026-27 scheme's own paper format has not been published yet — when your board paper is in your hand, its printed instructions govern.

Q1. (From: Forces & Equilibrium) — Answer any two of the following:

- (a) Describe briefly the different types of forces. Give one example of each type. **(6)**
- (b) Differentiate between the resultant and the equilibrant of a system of forces. **(6)**

(c) Two forces of 30 N and 40 N act at a point at right angles to each other. Calculate the magnitude of their resultant and its direction with respect to the 30 N force. (6)

Q2. (From: Friction) — Answer any two of the following:

(a) State and explain briefly the laws of friction. (6)

(b) Define angle of friction with a neat diagram. Derive the relation between the angle of friction and the coefficient of friction. (6)

(c) A block weighing 200 N rests on a horizontal surface. If the coefficient of friction between the block and the surface is 0.25, calculate the limiting frictional force. (6)

Q3. (From: Laws of Motion & Simple Machines) — Answer any two of the following:

(a) State Newton's three laws of motion and explain each law with one example. (6)

(b) Describe briefly levers and pulleys as simple machines. Give one example of each and state the benefit of using each. (6)

(c) A load of 500 N is to be pushed up a smooth inclined plane inclined at 30 degrees to the horizontal. Calculate the effort required, applied parallel to the plane. Neglect friction. (6)

Q4. (From: Centre of Gravity & Moment of Inertia) — Answer any two of the following:

(a) Define centre of gravity. State the position of the centre of gravity of a rectangle, a circle, a triangle and a semicircle. (6)

(b) Write a short note on moment of inertia. State what it depends upon, its unit and its use in brief. (6)

(c) Calculate the moment of inertia of a rectangular section 120 mm wide and 30 mm deep about its centroidal axis parallel to the base. Use $I = b \times d^3 / 12$. (6)

Q5. (From: Forces & Equilibrium + Friction (mixed)) — Answer any two of the following:

(a) State and explain briefly the conditions of equilibrium of a body under coplanar forces.

(b) Describe briefly the role of friction in simple machines. State its harmful and useful effects. (6)

(c) A block weighing 300 N rests on a horizontal surface. The coefficient of friction between the block and the surface is 0.4. Calculate the minimum horizontal force required to just move the block. (6)

Model Answer Outline — Engineering Mechanics

The key points a full-marks answer contains, question by question.

Practice Questions / Model Paper — NOT a BTEUP board paper

Q1(a)

- Force is a push or pull that changes or tries to change the state of rest or motion of a body, or its shape
- Any five types with a one-line example: muscular / applied force — pushing a trolley; gravitational force — a falling stone pulled by the earth
- Frictional force — opposes motion between surfaces in contact, e.g. between a block and the floor
- Tension — pull in a rope or string lifting a load; Normal reaction — upward push of a surface on a body resting on it
- Other acceptable types: spring force, magnetic force, electrostatic force — state that force is measured in newton (N)

Q1(b)

- Resultant: the single force which produces the same effect as all the given forces acting together
- Equilibrant: the single force which balances all the given forces and keeps the body in equilibrium
- Magnitude: resultant and equilibrant of the same force system are equal in magnitude
- Direction and sense: they act along the same line but in opposite directions; the equilibrant is opposite to the resultant
- Effect: resultant produces motion / the combined effect, while equilibrant produces no net effect — with a simple diagram of two forces and their resultant and equilibrant

Q1(c)

- Given: $P = 30 \text{ N}$ and $Q = 40 \text{ N}$ at right angles ($\theta = 90^\circ$) — Formula: $R = \sqrt{P^2 + Q^2}$
- Substitution: $R = \sqrt{30^2 + 40^2} = \sqrt{900 + 1600} = \sqrt{2500} = 50 \text{ N}$
- Formula for direction: $\tan \alpha = Q / P$, where α is the angle of the resultant with the 30 N force
- Substitution: $\tan \alpha = 40 / 30 = 1.333$, so $\alpha = \tan^{-1}(1.333) \approx 53.13^\circ$
- Final answers: Resultant = 50 N, acting at 53.13° to the 30 N force (towards the 40 N force) — note the 3-4-5 triangle check

Q2(a)

- Friction force is directly proportional to the normal reaction between the two surfaces
- Limiting friction is independent of the area of contact between the surfaces

- Limiting friction depends on the nature and roughness of the surfaces in contact
- Friction always acts opposite to the direction of motion or the direction in which motion is about to begin
- Static friction is slightly greater than kinetic (sliding) friction; friction is nearly independent of the speed at low speeds

Q2(b)

- Angle of friction is the angle that the resultant of the limiting friction force and the normal reaction makes with the normal reaction
- Define with a neat diagram: body on a surface, mark normal reaction R , limiting friction F , their resultant, and the angle ϕ at the normal
- When limiting friction is reached: $F = \mu R$, where μ is the coefficient of friction
- Relation: $\tan \phi = F / R = \mu R / R = \mu$ — Formula: $\mu = \tan \phi$
- State in a line: a larger coefficient of friction means a larger angle of friction

Q2(c)

- Given: $W = 200 \text{ N}$ on a horizontal surface, $\mu = 0.25$ — on a horizontal surface the normal reaction $R = W = 200 \text{ N}$
- Formula: Limiting friction $F = \mu \times R$
- Substitution: $F = 0.25 \times 200 = 50 \text{ N}$
- Final answer: Limiting frictional force = 50 N , acting opposite to the direction in which the block is pushed
- Meaning in a line: a horizontal force greater than 50 N is needed to just start the block moving

Q3(a)

- First law (law of inertia): a body remains at rest or in uniform motion in a straight line unless an external force acts on it — example: passengers jerk forward when a bus stops suddenly
- Second law: rate of change of momentum is proportional to the applied force and takes place in its direction; in simple form $F = m \times a$ — example: a heavier vehicle needs a larger force for the same acceleration
- Third law: every action has an equal and opposite reaction — example: a boat moves backward when a person jumps forward from it to the bank
- Define inertia in a line while explaining the first law: the tendency of a body to resist a change in its state

Q3(b)

- A simple machine is a device that helps to do work with less effort, or in a convenient direction
- Lever: a rigid bar that turns about a fixed point called the fulcrum; effort is applied at one point and the load is lifted at another — example: crowbar, scissors, balance

- Pulley: a wheel with a groove in which a rope passes; it changes the direction of the effort and, in a system of pulleys, also reduces the effort
- A single fixed pulley only changes direction; a movable pulley / pulley system gives mechanical advantage in brief
- One-line benefit of each: lever — a small effort moves a large load; pulley — a load can be lifted by pulling downwards

Q3(c)

- Given: Weight of load $W = 500 \text{ N}$, inclination $\theta = 30^\circ$, plane is smooth (friction neglected) — effort is applied parallel to the plane
- Formula: Effort $P = W \times \sin \theta$
- Substitution: $P = 500 \times \sin 30^\circ = 500 \times 0.5 = 250 \text{ N}$
- Final answer: Effort required = 250 N, applied parallel to the plane in the upward direction
- Check in a line: the effort (250 N) is less than the weight (500 N), so the inclined plane gives a mechanical advantage of $W / P = 2$

Q4(a)

- Centre of gravity (C.G.) is the point through which the whole weight of a body is supposed to act, in whatever position the body is placed
- Square / rectangle: C.G. is at the intersection of the diagonals, i.e. at the centre of the shape
- Circle: C.G. is at its centre
- Triangle: C.G. is at the point where the medians meet, at a height of $h/3$ from the base (h = height of the triangle)
- Semicircle: C.G. lies on its central radius at a distance of $4r / (3\pi)$ from the flat (diameter) side, where r is the radius — draw simple figures and mark the C.G. in each

Q4(b)

- Moment of inertia is the measure of the resistance of a body / section to bending or rotation, in the same way mass measures resistance to straight-line motion
- It depends on the total area / mass and on how far that area / mass is spread from the axis — the farther it is spread, the greater the moment of inertia
- Symbol I ; unit: mm^4 or cm^4 for an area (section), and $\text{kg}\cdot\text{m}^2$ for a mass, in brief
- Formula form in brief: $I = \sum a \times y^2$ for an area made of small parts a at distances y from the axis
- Use in brief: beams and machine parts are designed using moment of inertia, because a section with a higher value bends less under the same load

Q4(c)

- Given: width $b = 120 \text{ mm}$, depth $d = 30 \text{ mm}$ — Formula (about the centroidal axis parallel to the base): $I = b \times d^3 / 12$
- Substitution: $I = 120 \times 30^3 / 12 = 120 \times 27000 / 12$
- Calculation: $120 \times 27000 = 32,40,000$; divided by 12 gives 2,70,000

- Final answer: Moment of inertia = $2,70,000 \text{ mm}^4$ ($2.7 \times 10^5 \text{ mm}^4$)
- State in a line: the axis taken is the horizontal centroidal axis passing through the centre of the section

Q5(a)

- A body is in equilibrium when the net force and the net moment acting on it are both zero, so it does not move or rotate
- Algebraic sum of all horizontal components of forces is zero: $\Sigma F_x = 0$
- Algebraic sum of all vertical components of forces is zero: $\Sigma F_y = 0$
- Algebraic sum of moments of all forces about any point is zero: $\Sigma M = 0$
- Special case in a line: for three concurrent forces in equilibrium, each force is proportional to the sine of the angle between the other two (Lami's theorem, statement only is enough)

Q5(b)

- In simple machines friction acts between the moving parts and between the load and its guide / surface
- Harmful effect: part of the effort is wasted in overcoming friction, so the output work is less than the input work and the efficiency of the machine falls below 100%
- Parts under friction also get heated and wear out, so lubrication is used to reduce friction in machines
- Useful side in brief: some machines work only because of friction — e.g. a belt drive transmits power by friction, and a screw / wedge holds its load by friction
- Conclusion in a line: friction in machines is reduced where it wastes effort, but it cannot be removed completely

Q5(c)

- Given: $W = 300 \text{ N}$ on a horizontal surface, $\mu = 0.4$ — normal reaction $R = W = 300 \text{ N}$
- Minimum horizontal force to just move the block = limiting friction — Formula: $F = \mu \times R$
- Substitution: $F = 0.4 \times 300 = 120 \text{ N}$
- Final answer: Minimum horizontal force = 120 N
- Meaning in a line: any horizontal force less than 120 N will not move the block; motion just begins at 120 N