Newton's Laws of Motion (Advanced)

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer 8 × 1 = 8 marks

1. A lift accelerates upward at 3.5 m/s^2. For a 35 kg person inside it, the pseudo force seen from the lift's frame is:

(a) 465.5 N, downward **(b)** 122.5 N, upward
(c) 343 N, downward **(d)** 122.5 N, downward

2. Taking Earth's radius as 6,400 km and g = 9.8 m/s^2 at the surface, the value of g at a depth of 6,080 km is:

(a) 0.49 m/s^2 **(b)** 9.31 m/s^2 **(c)** 19.11 m/s^2 **(d)** 0.02 m/s^2

3. At a height 4R above the Earth's surface, the acceleration due to gravity becomes:

(a) 1/5 of its surface value **(b)** 1/26 of its surface value
(c) 1/125 of its surface value **(d)** 1/25 of its surface value

4. Taking R = 6,400 km, at what depth below the surface does g fall to 1/3 of its surface value? (Give the answer to 2 decimal places where needed.)

(a) 711.11 km **(b)** 2,133.33 km **(c)** 4,266.67 km **(d)** 12,800 km

5. A pseudo force is:

(a) the reaction to a real force
(b) a force due to contact between bodies
(c) the force of gravity
(d) an apparent force seen only from an accelerating frame

6. A force of 48 N acts on a spanner 0.7 m from the bolt, at 30° to the spanner. The torque about the bolt is:

(a) 16.8 N m **(b)** 68.57 N m **(c)** 33.6 N m **(d)** 67.2 N m

7. A rod is pivoted at its centre. 30 N acts downward 0.7 m to the left of the pivot and 45 N acts downward 0.2 m to the right. Seen from the front, what happens?

(a) It moves upward without turning **(b)** It does not turn: the torques balance
(c) It turns anticlockwise **(d)** It turns clockwise

8. Assertion (A): With R = 6,400 km, g at a depth of 3,200 km is 4.9 m/s^2.
Reason (R): Below the surface only the mass inside radius (R − d) pulls on a body, so g_d = g(1 − d/R).

(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. A bus starts suddenly with an acceleration of 6 m/s^2. For a 30 kg passenger, find (a) the pseudo force seen from inside the bus and (b) its direction (forward or backward).

10. An 85 kg student stands on a weighing scale in a lift that accelerates upward at 2.5 m/s^2. What does the scale read, in newtons? Take g = 9.8 m/s^2.

11. Find g at a height of 200 km above the Earth's surface. Take R = 6,400 km and g = 9.8 m/s^2 at the surface. (Give the answer to 2 decimal places where needed.)

12. Find g at a depth of 5,500 km below the Earth's surface. Take R = 6,400 km and g = 9.8 m/s^2 at the surface. (Give the answer to 2 decimal places where needed.)

13. At what depth below the surface is g equal to 2/5 of its surface value? Take R = 6,400 km. (Give the answer to 2 decimal places where needed.)

14. A force of 52 N is applied to a door 75 cm from its hinges, at 30° to the door. Find the torque about the hinges. (Give the answer to 2 decimal places where needed.)

15. A student opens a gate by pushing with 75 N at right angles, 50 cm from the hinge. How large a perpendicular force is needed at 40 cm from the hinge to produce the same torque? (Give the answer to 2 decimal places where needed.)

16. A mechanic needs a torque of 195 N m to loosen a bolt. What is the least force needed with a spanner 55 cm long? (Give the answer to 2 decimal places where needed.)

Section C — Word problems — 4 × 4 = 16 marks

17. A 35 kg person stands on a scale in a lift. Take g = 9.8 m/s^2. When the lift accelerates upward at 3.5 m/s^2, find (a) the pseudo force seen from inside the lift and (b) its direction (upward or downward), and (c) the scale reading. (d) What does the scale read when the lift accelerates downward at 3.5 m/s^2?

18. Take R = 6,400 km and g = 9.8 m/s^2 at the surface. Find g (a) at a height of 2,880 km and (b) at a depth of 2,880 km. (c) Where is g larger: at the height or at the depth? (Give the answer to 2 decimal places where needed.)

19. A force of 60 N is applied to a door 1.2 m from the hinge. Find the torque when the force is at (a) 90°, (b) 30° and (c) 0° to the door's surface.

20. On a see-saw, a child weighing 350 N sits 1.6 m from the pivot. (a) Find the torque of this child's weight about the pivot. (b) Where must a child weighing 300 N sit on the other side to balance it? (c) If the second child sits 1.8 m from the pivot instead, what is the net torque? (Give the answer to 2 decimal places where needed.)

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Answer key

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Q	Answer	Working
1	**(d) 122.5 N, downward**	F = m × a(frame) = 35 × 3.5, opposite to the frame's acceleration
2	**(a) 0.49 m/s^2**	g(1 − d/R) = 9.8 × (1 − 6,080/6,400)
3	**(d) 1/25 of its surface value**	g_h/g = R^2/(R + h)^2 = 1/(5)^2
4	**(c) 4,266.67 km**	1 − d/R = 1/3, so d = R × 2/3
5	**(d) an apparent force seen only from an accelerating frame**	it has no physical source
6	**(a) 16.8 N m**	τ = F d sin θ = 48 × 0.7 × sin 30° = 48 × 0.7 × 0.5
7	**(c) It turns anticlockwise**	left: 30 × 0.7 = 21 N m anticlockwise; right: 45 × 0.2 = 9 N m clockwise
8	**(d) A is false, but R is true.**	A is false: 9.8 × (1 − 3,200/6,400) = 4.9, not 4.9. R is true.
9	**(a) 180 N; (b) backward**	(a) 30 × 6; (b) opposite to the bus's acceleration
10	**1,045.5 N**	weight mg plus pseudo force ma, both downward: 85 × (9.8 + 2.5)
11	**9.22 m/s^2**	g_h = g × R^2/(R + h)^2 = 9.8 × 6,400^2/6,600^2
12	**1.38 m/s^2**	g_d = 9.8 × (1 − 5,500/6,400)
13	**3,840 km**	1 − d/R = 2/5, so d = 6,400 × 3/5
14	**19.5 N m**	τ = F d sin θ = 52 × 0.75 × 0.5
15	**93.75 N**	75 × 50 = F × 40
16	**354.55 N**	the least force acts at right angles at the end: F = τ ÷ d = 195 ÷ 0.55
17	**(a) 122.5 N; (b) downward; (c) 465.5 N; (d) 220.5 N**	(a) m × a = 35 × 3.5; (b) opposite to the lift's acceleration; (c) m(g + a); (d) m(g − a)
18	**(a) 4.66 m/s^2; (b) 5.39 m/s^2; (c) at the depth**	(a) 9.8 × 6,400^2/9,280^2; (b) 9.8 × (1 − 2,880/6,400); compare
19	**(a) 72 N m; (b) 36 N m; (c) 0 N m**	τ = F d sin θ with sin 90° = 1, sin 30° = 1/2, sin 0° = 0
20	**(a) 560 N m; (b) 1.87 m; (c) 20 N m**	(a) 350 × 1.6; (b) 300 × d = 560; (c) |300 × 1.8 − 560|

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