3.2 Mechanics: Forces and Newton's Laws: Test Pack

EDEXCEL 9MA0 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 State Newton's second law of motion in the form of an equation relating force, mass and acceleration.

(Total for Question 1 is 1 mark)

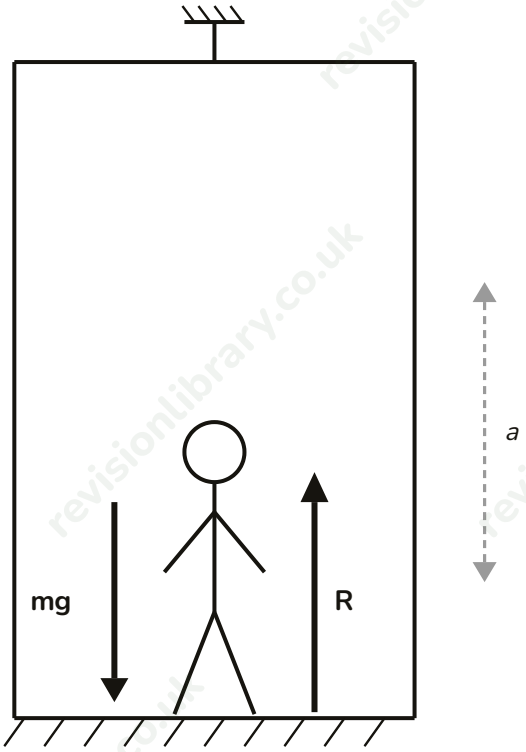
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2 State what is meant by modelling a string in mechanics as "light".

(Total for Question 2 is 1 mark)

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3 Priya, of mass 70 kg, stands on the floor of a lift. Take $g = 9.8$ m/s^2 and model Priya as a particle. In each case, find the normal reaction force R exerted on Priya by the lift floor (her apparent weight).



Priya, m = 70 kg
Lift may accelerate upward or downward, or move at constant velocity

(a) The lift accelerates upwards at 1.5 m/s^2. Find R. **(3)**

(b) The lift instead accelerates downwards at 1.5 m/s^2. Find R. **(3)**

(c) The lift moves at a constant velocity of 2 m/s upwards. Find R. **(2)**

(d) Explain, with reference to your answers above, why Priya feels heavier when the lift accelerates upwards and lighter when it accelerates downwards. **(2)**

(Total for Question 3 is 10 marks)

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4 Three forces act on a particle. Their components are given in the table below.

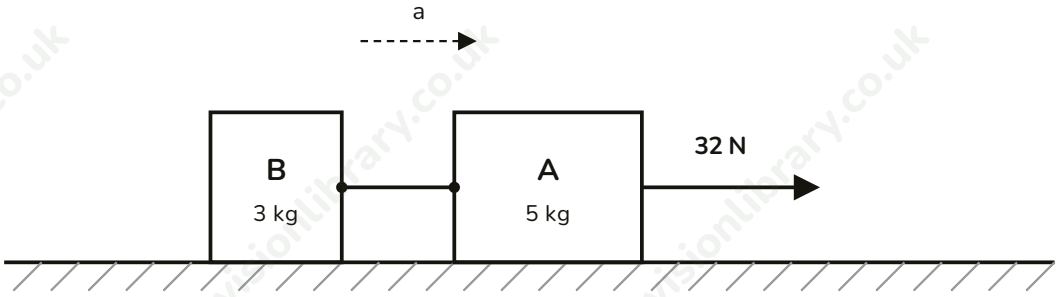
Force	i-component (N)	j-component (N)
F1	4	5
F2	3	1
F3	-1	2

Find the magnitude of the resultant force acting on the particle.

(Total for Question 4 is 2 marks)

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5 Two blocks A (mass 5 kg) and B (mass 3 kg) are connected by a light inextensible string. Block A is pulled by a horizontal force of magnitude 32 N, with the string joining A to B, which is behind A, so that A and B move together in a straight line with the same acceleration. Take g = 9.8 m/s^2.



(a) Given that the surface is smooth, find the acceleration of the system. **(3)**

(b) Find the tension in the string. **(3)**

(c) The surface beneath B is now rough, producing a constant resistance of 8 N to B's motion; the surface beneath A remains smooth. Find the new acceleration of the system and the new tension in the string. **(4)**

(Total for Question 5 is 10 marks)

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6 A block of mass 6 kg rests in limiting equilibrium on a rough plane inclined at 32 degrees to the horizontal. The block is on the point of sliding down the plane. Take g = 9.8 m/s^2. Find the coefficient of friction between the block and the plane, giving your answer to 3 significant figures.

(Total for Question 6 is 3 marks)

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7 A lift, of total mass 850 kg including passengers, accelerates upwards at 0.6 m/s^2. Take g = 9.8 m/s^2. Find the tension in the lift cable.

(Total for Question 7 is 3 marks)

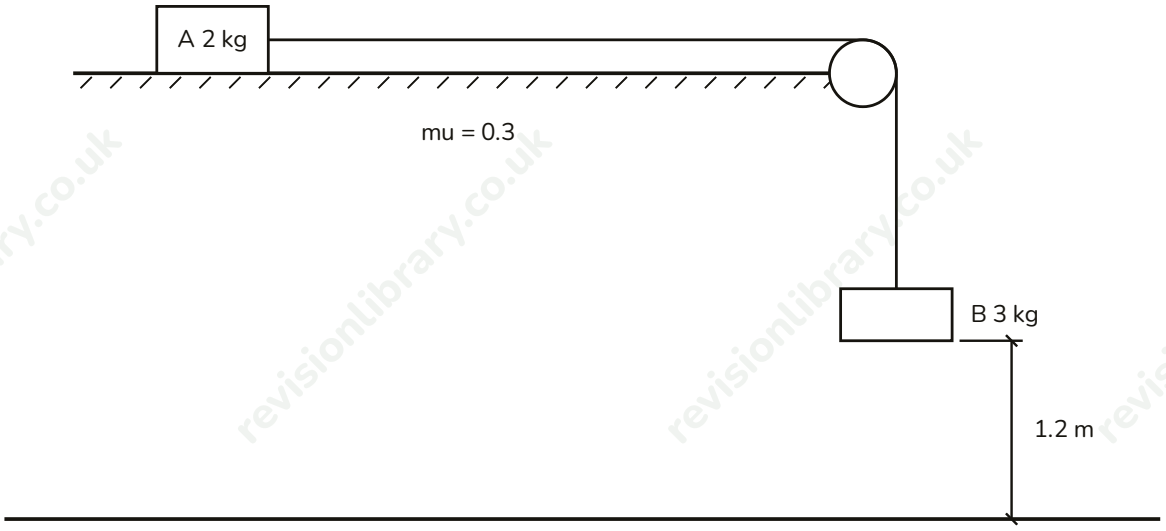
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8 A block of mass 5 kg is pulled up a rough plane inclined at 20 degrees to the horizontal by a force of magnitude 35 N acting parallel to the line of greatest slope. The coefficient of friction between the block and the plane is 0.2. Take g = 9.8 m/s^2. Show that the acceleration of the block is 1.81 m/s^2, correct to 3 significant figures.

(Total for Question 8 is 3 marks)

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9 Particle A, of mass 2 kg, lies on a rough horizontal table. Particle A is connected by a light inextensible string, passing over a smooth light pulley fixed at the edge of the table, to particle B, of mass 3 kg, which hangs freely 1.2 m above the floor. The coefficient of friction between A and the table is 0.3. The system is released from rest with the string taut. Take g = 9.8 m/s^2.



(a) Find the acceleration of the system and the tension in the string while B is falling. **(6)**

(b) Find the speed of B just before it reaches the floor. **(3)**

(c) When B lands, it does not rebound and the string becomes slack. Particle A continues moving across the table, decelerating due to friction alone. Find the additional distance A travels before it comes to rest. **(5)**

(d) State one modelling assumption made about the string, and explain what would happen to your answer to part (c) if the string had mass. **(2)**

(Total for Question 9 is 16 marks)

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Mark scheme · 3.2 Mechanics: Forces and Newton's Laws: Test Pack

Question 1

F = ma **B1**

Answer: F = ma

Question 2

it is assumed to have zero (negligible) mass **B1**

Answer: It has zero (negligible) mass.

Question 3

(a) equation of motion R - mg = ma with a = +1.5 (upward taken as positive) **M1**

(a) R = 70(9.8 + 1.5) (oe) **A1**

(a) R = 791 N cao **A1**

(a) Answer: R = 791 N

(b) equation of motion mg - R = ma with a = 1.5 downward, or R = m(g - a) **M1**

(b) R = 70(9.8 - 1.5) (oe) **A1**

(b) R = 581 N cao **A1**

(b) Answer: R = 581 N

(c) recognising a = 0 so R = mg **B1**

(c) R = 686 N cao **B1**

(c) Answer: R = 686 N

(d) R > mg (791 > 686) when accelerating upwards, and R is what Priya feels supporting her, so she feels heavier **B1**

(d) R < mg (581 < 686) when accelerating downwards, so she feels lighter **B1**

(d) Answer: R is greater than her true weight when accelerating up, and less than her true weight when accelerating down; apparent weight equals R.

Question 4

resultant = (4+3-1)i + (5+1+2)j = 6i + 8j (oe) **M1**

10 cao **A1**

Answer: 10 N

Question 5

(a) whole system equation: 32 = (5 + 3)a (oe) **M1**

(a) 8a = 32 (oe) **A1**

(a) a = 4 m/s^2 cao **A1**

(a) Answer: a = 4 m/s^2

(b) equation of motion for B alone: T = mB a (oe) **M1**

(b) T = 3 x 4 (oe) **A1**

(b) T = 12 N cao **A1**

(b) Answer: T = 12 N

(c) whole system equation: 32 - 8 = (5+3)a (oe) **M1**

(c) a = 3 m/s^2 cao **A1**

(c) equation of motion for B: T - 8 = 3a **M1**

(c) T = 17 N cao **A1**

(c) Answer: a = 3 m/s^2, T = 17 N

Question 6

resolve perpendicular to the plane: R = mg cos32 (oe) **M1**

resolve parallel to the plane, with friction acting up the slope since the block is about to slide down: mg sin32 = μ R (oe) **M1**

awrt 0.625 **A1**

Answer: 0.625 (3 s.f.)

Question 7

equation of motion T - mg = ma, with a=+0.6 (upward positive) **M1**

T = 850(9.8+0.6) (oe) **A1**

8840 N cao **A1**

Answer: 8840 N

Question 8

resolve perpendicular to the plane: R = mg cos20 (oe) **M1**

resolve parallel to the plane: 35 - mg sin20 - μ R = ma (oe) **M1**

cso: correct working leading to 1.81 (3 s.f.) **A1**

Answer: a = 1.81 m/s^2 (3 s.f.), as given.

Question 9

(a) equation of motion for A: T - F = mA a, with friction F = μ mA g **M1**

(a) equation of motion for B: mB g - T = mB a **M1**

(a) F = 0.3(2)(9.8) = 5.88 N correctly found **A1**

(a) eliminate T by combining the two equations to solve for a **dM1**

(a) a = 4.70 m/s^2 (awrt) **A1**

(a) T = 15.3 N (awrt) **A1**

(a) Answer: a = 4.70 m/s^2, T = 15.3 N

(b) $v^2 = u^2 + 2as$ with u=0, a=4.704, s=1.2 **M1**

(b) v^2 = 11.2896 (oe, ft on a from part (a)) **A1**

(b) v = 3.36 m/s cao **A1**

(b) Answer: v = 3.36 m/s

(c) recognising new deceleration of A is μ g (friction only, no tension) = 2.94 m/s^2 **M1**

(c) correct value of deceleration, ft from μ used in part (a) **A1ft**

(c) use $v^2 = u^2 - 2as$ with u = 3.36 (ft from part (b)), v = 0 **M1**

(c) s = 11.2896/5.88 (oe, ft on u from part (b)) **A1ft**

(c) s = 1.92 m cao **A1**

(c) Answer: 1.92 m

(d) the string is modelled as light (massless) and inextensible **B1**

(d) if the string had mass, its weight would affect the tension and the equations of motion in part (a), changing the acceleration and hence the speed used in part (c); the calculation in part (c) itself (friction only, string slack) would be unaffected once the string is slack, but the speed carried into it would differ **B1**

(d) Answer: String assumed light; a heavier string would change the acceleration and speed found earlier, altering the distance in part (c) even though the deceleration mechanism itself (friction only) stays the same.

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