End of Chapter Revision Sheet: Newton's Laws 5th Year

Level 1:

Q1. A team of huskies pulls a sled of mass $400\ kg$ from rest across $200\ m$ of a smooth icy surface in $40\ s$. Find the force exerted by the huskies if the rope remains horizontal throughout. Assume also that there is no friction.

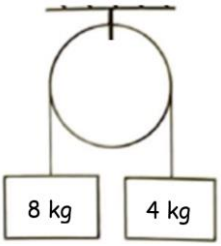
Q2. A particle of mass 30 grams is dropped from the top of a building that is $50\ m$ high.
(i) Find the time taken for the particle to hit the ground, assuming no air resistance.
(ii) If there was a constant air resistance force, and the particle takes twice as long to hit the ground, find the air resistance force.

Q3. A lift of mass $300\ kg$ accelerates up and down at the same rate of $3\ m/s^2$. Find the tension in the lift cable when the lift is:
(i) Accelerating up at $3\ m/s^2$
(ii) Accelerating down at $3\ m/s^2$.

Q4. A soccer player starts a sliding tackle at a speed of $9\ m/s$. If the coefficient of friction between him and the ground is 0.3, find what distance he slides before stopping.

Q5. A van of mass $3000\ kg$ is travelling along a horizontal road at a constant speed of $30\ m/s$, when the ignition is turned off. The car then rolls to a stop under friction. If the coefficient friction between the van and the road surface is 0.4, find the time taken for the van to stop.

Q6. Two particles of mass $8\ kg$ and $4\ kg$ are hanging freely from each side of a smooth fixed pulled as shown on the right. The system is released from rest.
(i) Find the common acceleration of the two particles.
(ii) Find the tension in the string.
(iii) Find the time taken for the $4\ kg$ particle to rise $0.5\ m$.

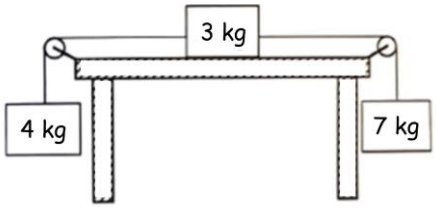


Q7. A lift of mass $1200\ kg$ and carrying 3 people of mass $60\ kg$ is descending a lift shaft with an acceleration of $2.5\ m/s^2$.
(i) Find the tension in the lift cable.
(ii) Find the normal reaction between the floor of the lift and one of the passengers.

Q8. A sled of mass $300\ kg$ is pulled across the snow by a rope that is inclined at $20°$ above the horizontal. If the coefficient of friction between the sled and the snow is $\frac{1}{4}$, and the acceleration of the sled is $1.5\ m/s^2$, find the tension in the rope.

Level 2:

Q9. Three particles of mass $4\ kg$, $3\ kg$ and $7\ kg$ are set up as shown in the diagram on the right. The coefficient of friction on the table is $\frac{1}{4}$ and the system is released from rest.
(i) Find the common acceleration of the three masses.
(ii) Find their speed after $1.5\ s$.
(iii) If after $1.5\ s$, the string joining the $3\ kg$ and the $7\ kg$ particle is cut, find how much further the $4\ kg$ mass would rise.



Q10. A go-kart runs down a hill of incline $\sin^{-1}\frac{1}{100}$ and on reaching the foot of the hill, runs along a horizontal road. The resistance to motion is the same on both the hill and on the horizontal. Find how far it would run on the horizontal before coming to rest, if it descended the hill at a steady speed of $10\ m/s$.

Q11. A fixed smooth pulley has masses of $4\,kg$ and $2\,kg$ hanging from either side of a light inextensible string. The system is released from rest with the $4\,kg$ mass $3\,m$ above a table.

(i) Find the common acceleration of the two masses.

(ii) Find their speed when the $4\,kg$ particle hits the table.

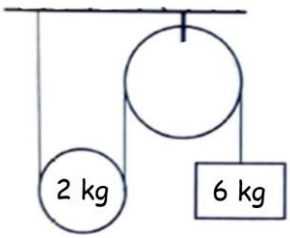
(iii) How much further the $2\,kg$ mass will rise?

(iv) The 4 kg mass is brought to rest when it hits the table. At a time t later, the string becomes taut again. Find the value of t.

Q12. A particle of mass $4\,kg$ is dragged up a plane that is inclined at $45°$ to the horizontal, using a rope that is inclined at $\tan^{-1}\frac{4}{3}$ above the plane. If the coefficient of friction is $\frac{1}{3}$, find the tension in the rope if the particle is accelerating at $2\,m/s^2$.

Q13. Find the acceleration of all movable particles in the diagrams below, assuming all pulleys are smooth. All surfaces shown have a coefficient of friction of $\frac{1}{2}$.

(i)



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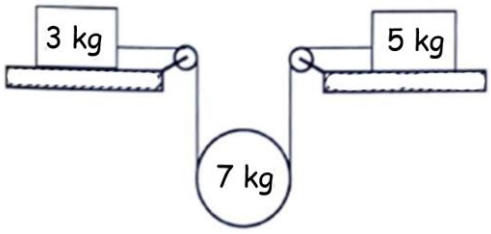

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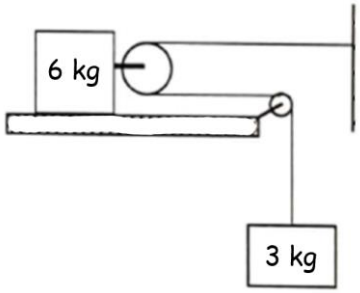

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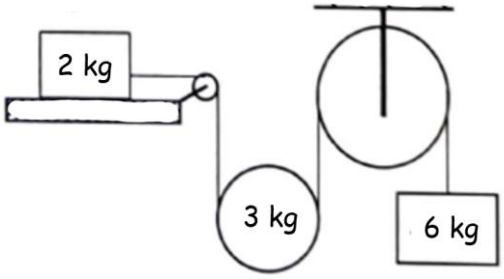


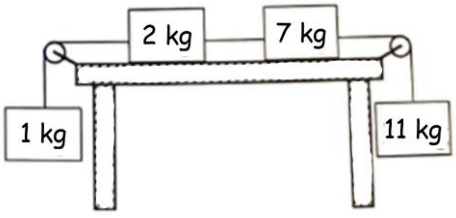
Level 3:

Q14. A motorbike accelerates from rest under a constant tractive force of $150\,N$. After moving $250\,m$ the engine stalls and the car slows down to rest, without the brakes being applied. Assuming a constant resistance of $40\,N$ throughout the motion, calculate the total distance travelled.

Q15. Four particles of mass $1\,kg$, $2\,kg$, $7\,kg$ and $11\,kg$ are set up as shown in the diagram on the right. The system is released from rest.

(i) If the table is smooth, find the common acceleration of the four masses.

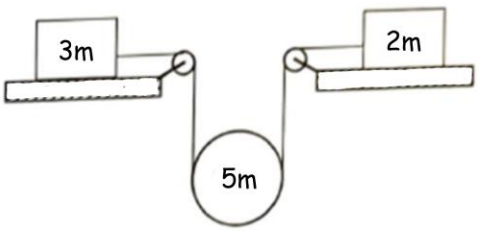
(ii) Find the percentage reduction in this acceleration if the table is rough with a coefficient of friction of $\frac{1}{3}$.



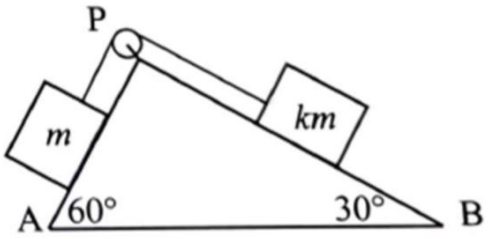
Q16. Three particles are set up as shown in the diagram on the right. The coefficient of friction between the $3m$ mass and the table is μ, and between the $2m$ mass and its table is $\frac{1}{3}$. The pulley is smooth.

(i) Prove that the tension in the string is $\frac{mg(70+30\mu)}{49}$.

(ii) Prove that A will not move if $\mu > \frac{70}{117}$.



Q17. Two particles of mass $m\ kg$ and $km\ kg$ are connected as shown in the diagram on the right, on a smooth faced wedge that is fixed in place.

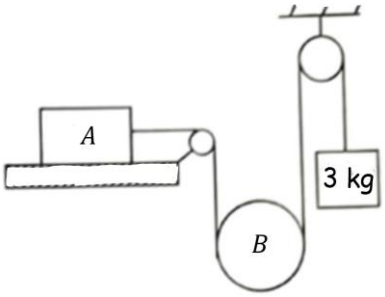


(i) Show that the particle of mass m will accelerate towards P, provided $k > \sqrt{3}$.

(ii) If $k = 2$, find the tension in the string, in terms of m.

(iii) If $k = 2$, and the planes PA and PB are rough and the coefficient of friction between each particle and the plane is μ, show that the particle of mass m will move towards P if $\mu < \frac{2-\sqrt{3}}{1+2\sqrt{3}}$.

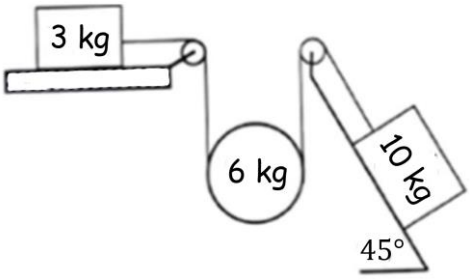
Q18. Three particles are arranged as shown in the diagram on the right-hand side. Particle A has mass m_1 and the movable pulley B has mass m_2. A is on a smooth surface. The system is released from rest.



(i) Prove that the tension in the string is: $\frac{9m_1m_2g}{12m_1+3m_2+m_1m_2}$.

(ii) Show that, if pulley B remains at rest, then: $\frac{6}{m_2} - \frac{3}{m_1} = 1$.

Q19. Three particles are set up as shown in the diagram on the right-hand side. The coefficient of friction between the $3\ kg$ mass and the plane is $\frac{1}{3}$. The coefficient of friction between the $10\ kg$ mass and the inclined plane is $\frac{1}{2}$. When the system is released from rest, the $10\ kg$ particle slides down the inclined plane. Find the acceleration of each of the particles and the movable pulley.



Answers:

Q1. $100\ N$	Q2. (i) $3.2\ s$ (ii) $0.22N$	Q3. (i) $3840\ N$ (ii) $2040N$	Q4. $13.78\ m$	Q5. $7.65\ s$
Q6. (i) $3.27\ m/s^2$ (ii) $52.27\ m/s^2$ (iii) $0.55\ s$		Q7. (i) $10074\ N$ (ii) $438\ N$	Q8. $1155.87\ N$	
Q9. (i) $1.58m/s^2$ (ii) $2.36\ m/s$ (iii) $0.42\ m$		Q10. $510.2\ m$	Q11. (i) $3.27\ m/s^2$ (ii) $4.43\ m/s$ (iii) $1\ m$ (iv) $0.9\ s$	
Q12. $51.87\ N$	Q13. (i) $3.77\ m/s^2, 7.54\ m/s^2$ (ii) $3.97m/s^2, 0.42m/s^2, 2.2\ m/s^2$ (iii) $3.27\ m/s^2, 1.63\ m/s^2$ (iv) $3.675\ m/s^2, 6.94\ m/s^2$			
Q14. $687.5\ m$	Q15. (i) $4.67\ m/s^2$ (ii) 29.33%	Q17 (ii) $8.92m$	Q19. $4.71\ m/s^2, 1.07\ m/s^2, 1.82\ m/s^2$	

Past Exam Questions:

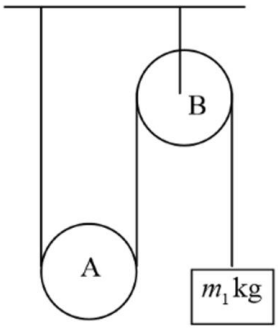
2007 Q4(a)

(a) A particle slides down a rough plane inclined at $45°$ to the horizontal. The coefficient of friction between the particle and the plane is $\frac{3}{4}$.

Find the time of descending a distance 4 metres from rest.

2008 Q4(a)

(a) The diagram shows a light inextensible string having one end fixed, passing under a smooth movable pulley A of mass m kg and then over a fixed smooth light pulley B.
The other end of the string is attached to a particle of mass m_1 kg.

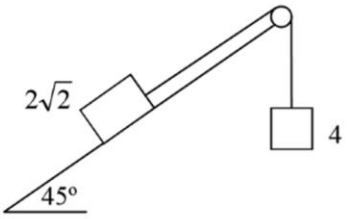


The system is released from rest.

Show that the upward acceleration of A is $\frac{(2m_1 - m)g}{4m_1 + m}$.

2011 Q4(a)

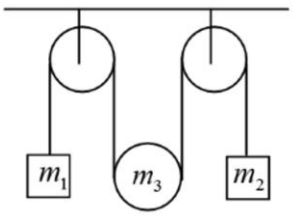
(a) A block of mass $2\sqrt{2}$ kg rests on a rough plane inclined at 45° to the horizontal. It is connected by a light inextensible string which passes over a smooth, light, fixed pulley to a particle of mass 4 kg which hangs freely under gravity.
The coefficient of friction between the block and the plane is $\frac{1}{4}$.



Find the acceleration of the 4 kg mass.

2013 Q4(b)

(b) A light inextensible string passes over a smooth fixed pulley, under a movable smooth pulley of mass m_3, and then over a second smooth fixed pulley.



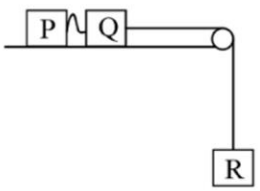
A particle of mass m_1 is attached to one end of the string and a particle of mass m_2 is attached to the other end.

The system is released from rest.

Find the tension in the string in terms of m_1, m_2 and m_3.

2015 Q4(a)

4. (a) Two particles P and Q, of mass 4 kg and 7 kg respectively, are lying 0.5 m apart on a smooth horizontal table. They are connected by a string 3.5 m long. Q is 6 m from the edge of the table and is connected to a particle R, which is of mass 3 kg and is hanging freely, by a taut light inextensible string passing over a light smooth pulley.



The system is released from rest.

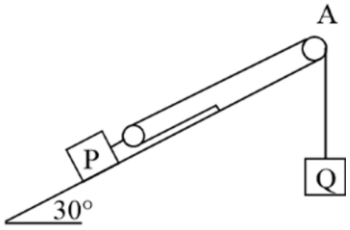
Find

(i) the initial acceleration of Q and R

(ii) the speed of Q when it has moved 3 m

2016 Q4(a)

4. **(a)** The block P has a light pulley fixed to it. The two blocks P and Q, of mass 40 kg and 30 kg respectively, are connected by a taut light inextensible string passing over a light smooth fixed pulley, A, as shown in the diagram.



P is on a rough plane which is inclined at 30° to the horizontal. The coefficient of friction between P and the inclined plane is $\frac{1}{4}$.

Q is hanging freely. The system is released from rest.

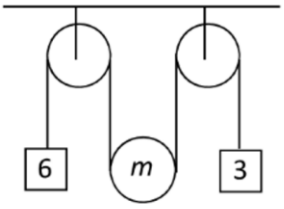
Find

(i) the acceleration of P and the acceleration of Q

(ii) the speed of P when it has moved 30 cm.

2018 Q4(b)

(b) A moveable pulley of mass *m* is suspended on a light inextensible string between two fixed pulleys as shown in the diagram. Masses of 6 kg and 3 kg are attached to the ends of the string.



The system is released from rest.

(i) Show, on separate diagrams, the forces acting on the moveable pulley **and** on each of the masses.

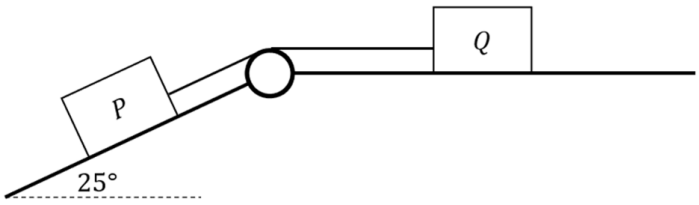
(ii) Find in terms of *m* the tension in the string.

(iii) For what value of *m* will the acceleration of the moveable pulley be zero?

2023 Q5(a)

Question 5

(a) Block P (of mass 6.3 kg) and block Q (of mass 2.5 kg) are held at rest on a rough surface. They are connected by a light inextensible string which passes over a smooth fixed pulley. Block Q lies on the horizontal part of the surface and block P lies on the part of the surface that is inclined at 25° to the horizontal, as shown in the diagram.



The coefficient of friction between each block and the surface is 0.2.

The blocks begin to move when they are released.

(i) Show, on separate diagrams, the forces acting on the blocks while they are moving.

(ii) Calculate the acceleration of the blocks.

Past Exam Questions:

2007: $2.15\ s$	2011: $2.15\ m/s^2$	2013: (b) $T = \frac{4m_1m_2m_3g}{m_1m_3+m_2m_3+4m_1m_2}$	2015: (i) $\frac{3g}{10}$ or $2.94\ m/s^2$ (ii) $4.2\ m/s$	
2016: (i) $1.92\ m/s^2, 3.84\ m/s^2$ (ii) $1.07\ m/s$		2018: (ii) $\frac{8mg}{m+8}$ (iii) $8\ kg$		2023: (ii) $1.14\ m/s^2$