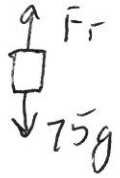
1. A parachutist of mass 75 kg, whose parachute only partly opens, accelerates downwards at 1 m/s2. What upwards force must her parachute be providing?

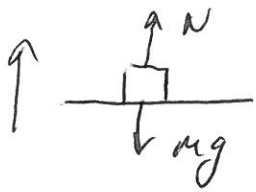


$75g - F_r = 75 \times 1$

$F_r = 75(g - 1)$

$= 660\,N$

2. In a lift that is accelerating upwards at 2 m/s2, a spring balance shows the mass ~~apparent weight~~ of an object to be 2.5 kg ~~wt~~. What would be the reading if the lift were at rest?



$N - mg = ma$

$N = mg + ma$

$m = \frac{N}{g + a}$ $\quad m = \frac{2.5 \times 9.8}{9.8 + 2} = 2.08\,kg$

✳ 3. In a lift that is accelerating downwards at 1 m/s2, a spring balance shows the mass of an object to be 2.5 kg. What would be the reading if the lift were:

a at rest

b accelerating upwards at 2 m/s2?

a) $mg - N = ma$

$m = \frac{N}{m(g - a)}$ $\quad m = \frac{2.5 \times 9.8}{9.8 - 1} = 2.78\,kg$

b) $N - mg = ma$ $\quad m = \frac{N}{g + a}$ $\quad m = 2$

$N = m(g + a)$ $\quad N = 2.78 \times 11.8 = 32.8\,N$

$m_1 = \frac{N}{g} = 3.35\,kg$

4. A box of mass 10 kg lies on the horizontal floor of a lift which is accelerating upwards at 1.5 m/s2. Find the reaction, in newtons, of the lift floor on the box.

$N - mg = ma$

$N = m(g + a)$

$N = 10(9.8 + 1.5)$

$= 113\,N$

5. One man can push a wardrobe of mass 250 kg with an acceleration of magnitude 0.15 m/s2. With help from another man pushing just as hard (i.e. with the same force), the wardrobe accelerates at 0.4 m/s2. How hard is each man pushing and what is the resistance to sliding?

$F - F_r = ma_1 \quad 2F - F_r = ma_2$

$F - F_r = 250 \times 0.15$

$2F - F_r = 250 \times 0.4 \quad F_r = F - ma_1$

$F = 250(0.4 - 0.15) \quad F_r = 62.5 - 250 \times 0.1$

$F = 62.5\,N \quad = 25\,N$

6. A load of 200 kg is being raised by a cable. Find the tension in the cable when:

a the load is lifted at a steady speed of 2 m/s

b the load is lifted with an upwards acceleration of 0.5 m/s2.

a) $T - mg = 0$

$T = 200 \times 9.8 = 1960\,N$

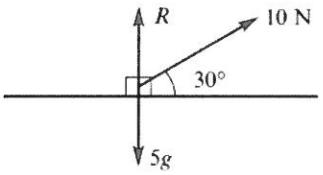
b) $T - mg = ma$

$T = m(g + a)$

$T = 200(9.8 + 0.5) = 2060\,N$

7. Find the acceleration of a 5 kg mass for each of the following situations:

a)



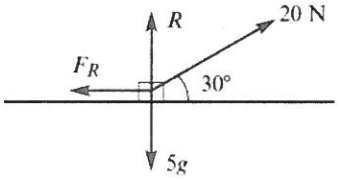
smooth surface

$10\cos 30^\circ = 5a$

$a = 2\cos 30$

$= 1.7\,ms^{-2}$

* b) Resistive force is 5 N

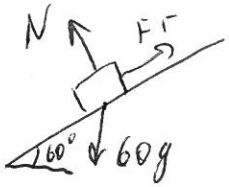


$20\cos 30^\circ - F_r = 5a$

$a = \dfrac{20\cos 30^\circ - 5}{5}$

$a = 2.5\,ms^{-2}$

8. A 60 kg woman skis down a slope that makes an angle of 60◦ with the horizontal. The woman has an acceleration of 8 m/s2. What is the magnitude of the resistive force?

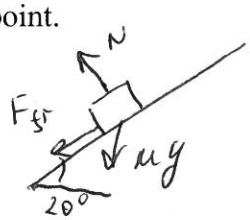


$mg\sin\theta - F_r = ma$

$F_r = 60\times 9.8\sin 60^\circ - 60\times 8$

$= 29.2\ N$

✳ 9. A 3 kgbody is projected up an incline of 20◦ with a velocity of 10 m/s. If the friction force between the body and the plane is 5 N, find the distance it goes up the plane and the velocity with which it returns to its starting point.

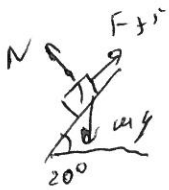


$mg\sin 20^\circ + F_{fr} = ma_1$

$a_1 = \dfrac{3\times 9.8\times\sin 20^\circ + 5}{3}$ $\quad a = 5\ ms^{-2}$

~~$s = ut$~~ $\quad v^2 = u^2 + 2as$

$0 = 10^2 - 2\times 5s \quad s = 10\ m$



$mg\sin 20^\circ - F_r = ma_2$

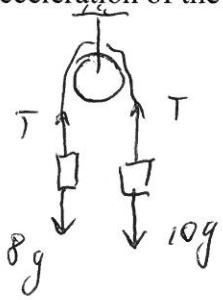
$a_2 = \dfrac{3\times 9.8\times\sin 20^\circ - 5}{3}$ $\quad a = 1.7\ ms^{-2}$

$v^2 = 2\times 1.7\times 10 \quad v = 5.8\ ms^{-1}$

✳ 10. Two masses of 8 kg and 10 kg are suspended by a light inextensible string over a smooth pulley.

a Find the tension in the string.

b Find the acceleration of the system.



$10g - T = 10a$

$T - 8g = 8a$

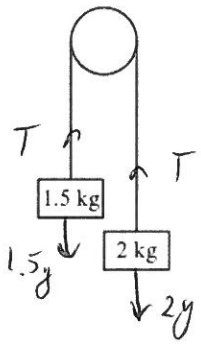
$2g = 18a$

$a = \dfrac{g}{9} \quad a = 1.09 \approx 1.1\ ms^{-2}$

$T = 8(9.8 + 1.1)$

$= 87.2\ N$

11. A mass of 1.5 kg is connected to a mass of 2 kg by a light inelastic string which passes over a smooth pulley as shown. Find:
a the tension in the string
b the acceleration of the system.



$2g - T = 2a$

$T - 1.5g = 1.5a$

$0.5g = 3.5a$

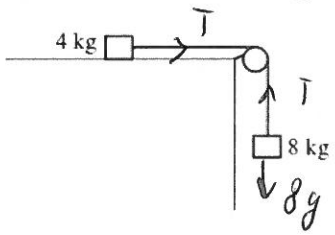
$a = \frac{g}{7}$

$a = 1.4\ ms^{-2}$

$T = 1.5(9.8 + 1.4)$

$= 16.8\ N$

12. The diagram shows a particle of mass 4 kg on a smooth horizontal table.
The particle is connected by a light inelastic string which passes over a smooth pulley to a particle of mass 8 kg which hangs vertically. Find:
a the acceleration of the system
b the tension in the string.



$8g - T = 8a$

$T = 4a$

$8g = 12a$

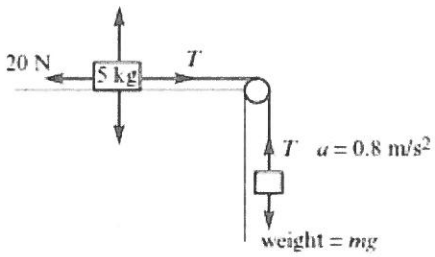
$a = \frac{2g}{3}$

$a = 6.5\ ms^{-2}$

$T = 4a$

$= 26\ N$

13. In the situation shown in the diagram, what mass *m* kg is required in order to give the system an acceleration of 0.8 m/s2?



$m_1 g - T = m_1 a$

$T - 20 = m_2 a$

$T = 20 + 5 \times 0.8$

$T = 24\ N$

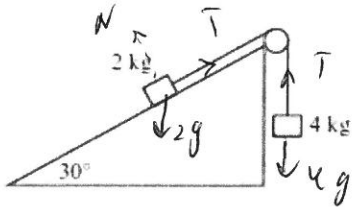
$m_1 (g - a) = T$

$m_1 = \frac{24}{9.8 - 0.8} = 2.7\ kg$

14. A mass of 2 kg, resting on a smooth plane inclined at 30° to the horizontal, is connected to a mass of 4 kg by a light inelastic string which passes over a smooth pulley, as shown in the diagram. Find:

a the tension in the string

b the acceleration of the system.



$4g - T = 4a$

$T - 2g\sin 30° = 2a$

$4g - 2g\sin 30° = 6a$

$a = \dfrac{4g - 2g\sin 30°}{6}$

$a = 4.9\ m\,s^{-2}$

$T = 4(9.8 - 4.4)$

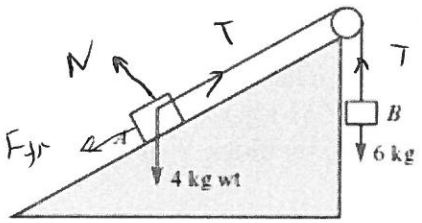
$= 19.6\ N$

$4g - T = 4 \times 4.9$

* 15. Two blocks *A* and *B*, of masses 4 kg and 6 kg respectively, are connected by a light string passing over a smooth pulley. Block *A* rests on a rough plane inclined at 30° to the horizontal. When the blocks are released from rest, block *B* moves downwards with an acceleration of 1 m/s2.

a Calculate the value of the friction force between *A* and the inclined plane.

b Find the tension in the string connecting *A* and *B*.



$6g - T = 6a$

$T - 4g\sin 30° - F_{fr} = 4a$

$6g - 4g\sin 30° - F_{fr} = 10a$

$F_{fr} = 6g - 4g\sin 30° - 10a$

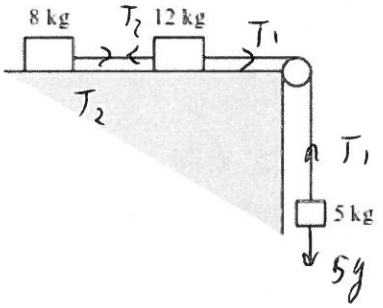
$F_{fr} = 29.2\ N$

$T = 6(g - a)$

$T = 52.8\ N$

✳ 16. The diagram shows masses of 8 kg and 12 kg lying on a smooth horizontal table and joined, by a light inextensible string, to a mass of 5 kg hanging freely. This string passes over a smooth pulley at the edge of the table. The system is released from rest. Find:

a the tension in the string connecting the 8 kg and 12 kg masses
b the tension in the string connecting the 12 kg and 5 kg masses
c the acceleration of the system.



$5g - T_1 = 5a$

$T_1 - T_2 = 12a$

$T_2 = 8a$

$T_1 = 20a$

$5g - 20a = 5a$

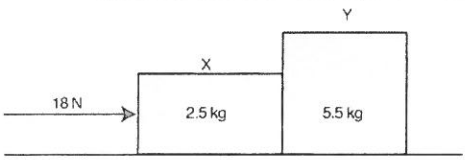
$a = \frac{g}{5}$ $a = 1.96\ m\,s^{-2}$

$T_2 = 8 \times 1.96$

$= 15.7$ ~~$m\,s^{-2}$~~ N

$T_1 = 20 * 1.96 = 39.2\ N$

17. Consider the two blocks shown in the diagram. They are resting on a surface which provides a frictional force of 0.25 N/kg. Calculate the acceleration of the system and the force exerted by block Y on X.



$18 - F_{fr} = 8a$

$18 - 0.25 \times 8 = 8a$

$a = 2\ m\,s^{-2}$

Force by block Y on X equal to force by X on Y.

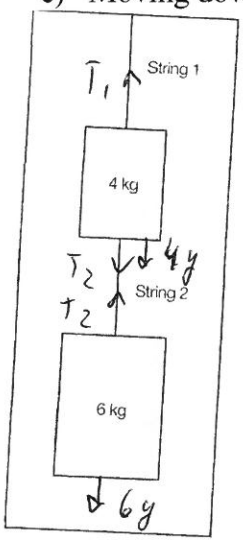
$F - 0.25 \times 5.5 = 5.5a$

$F = 12.375\ N$

And this force (X on Y) is the force pushing Y forward.

18. Two masses are connected by a string and hanging from the ceiling of a lift. Find tension in each string if elevator:

a) Moving up at 3.0 m/s
b) Moving up with acceleration 3.0 m/s2
c) Moving down with acceleration 3.0 m/s2



a) $T_1 = 10g = 98N$

$T_2 = 6g = 58.8N$

b) $T_2 - 6g = 6a$ $\quad T_2 = 6(g+a)$ $\quad T_2 = 76.8N$

$T_1 - 4g - T_2 = 4a$

$T_1 = 4g + T_2 + 4a$

$T_1 = 128N$

c) $6g - T_2 = 6a$

$4g + T_2 - T_1 = 4a$

$T_2 = 6(g-a) = 40.8N$

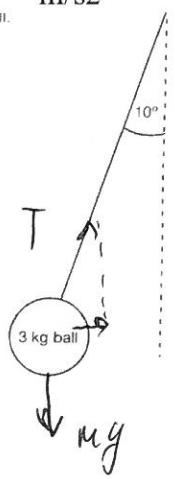
$T_1 = 4g + T_2 - 4a$

$T_1 = 68N$

19. A ball is hanging by a string from the ceiling of a bus as shown in the diagram.

a) Find acceleration of the bus.
b) At what angle would be the ball and string hang if the bus was breaking at 2.5 m/s2

the ball.



a) $T \sin 10^\circ = 3a$

$T \cos 10^\circ - 3g = 0$

$T = \dfrac{3g}{\cos 10^\circ}$

$T = 29.85\ N$

$a = \dfrac{T \sin 10^\circ}{3}$ $\quad a = 1.7\ m\,s^{-2}$

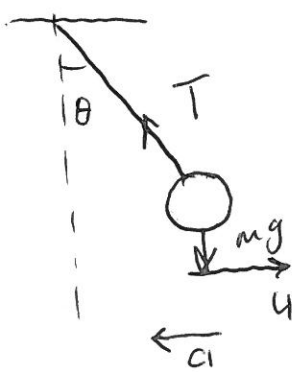
b) $T \sin\theta = 3a$ (1)

$T \cos\theta = 3g$ (2) $\quad$ (1) ÷ (2)

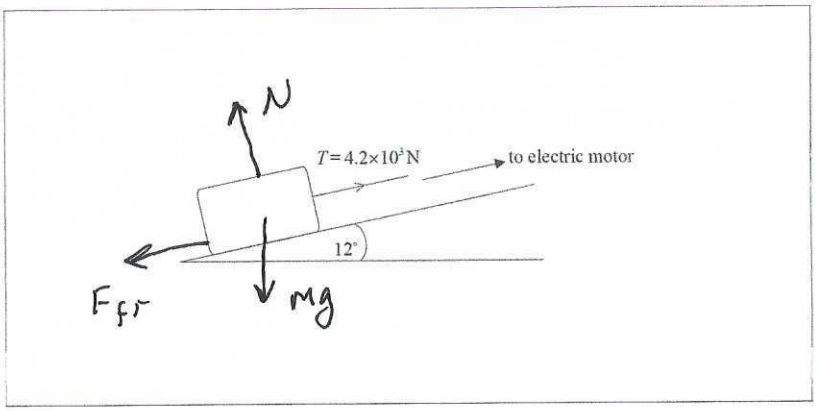
$\tan\theta = \dfrac{a}{g}$

$\theta = \tan^{-1}\left(\dfrac{a}{g}\right)$

$= 14.3^\circ$



20. A stone block is pulled at constant speed up an incline by a cable attached to an electric motor.



$= mg$

The incline makes an angle of 12 ° with the horizontal. The weight of the block is 1.5×10^4 N and the tension T in the cable is 4.2×10^3 N. Calculate the magnitude of the friction force acting on the block.

$$T - mg\sin\theta - F_{fr} = 0$$

$$F_{fr} = T - mg\sin\theta = 4.2\times10^{3} - 1.5\times10^{4}\times\sin 12^{\circ}$$

$$= 1081\ N$$

21. A body of mass 8 kg rests on a plane of inclination 20°.

a) Find the friction force.

$$F_{fr} = mg\sin\theta$$

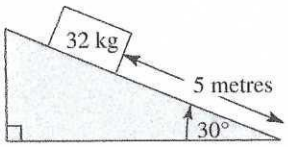
$$= 8\times9.8\sin20^{\circ} = 26.8\ N$$

b) If the inclination is increased to 35°, find the acceleration down the plane assuming that friction force remains the same.

$$mg\sin\theta - F_{fr} = ma$$

$$a = \frac{mg\sin\theta - F_{fr}}{m} = \frac{8\times9.8\sin35^{\circ} - 26.8}{8} = 2.27\ ms^{-2}$$

22. A mass of 32 kg starts from rest on a smooth plane inclined at 30° to the horizontal.



After it travels 5 metres down the plane its velocity is:

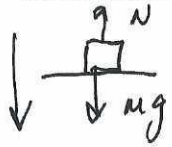
$$a = g\sin\theta = 9.8\sin30^{\circ} = 4.9\ ms^{-2}$$

$$v^2 = u^2 + 2as$$

$$v^2 = 2\times4.9\times5$$

$$v = 7\ ms^{-1}$$

23. An empty lift that has a mass of 800 kg is entered by a person of mass 50 kg. It then descends at its maximum acceleration of 1.5 m/s^2. Calculate the force exerted on the person by the lift floor.



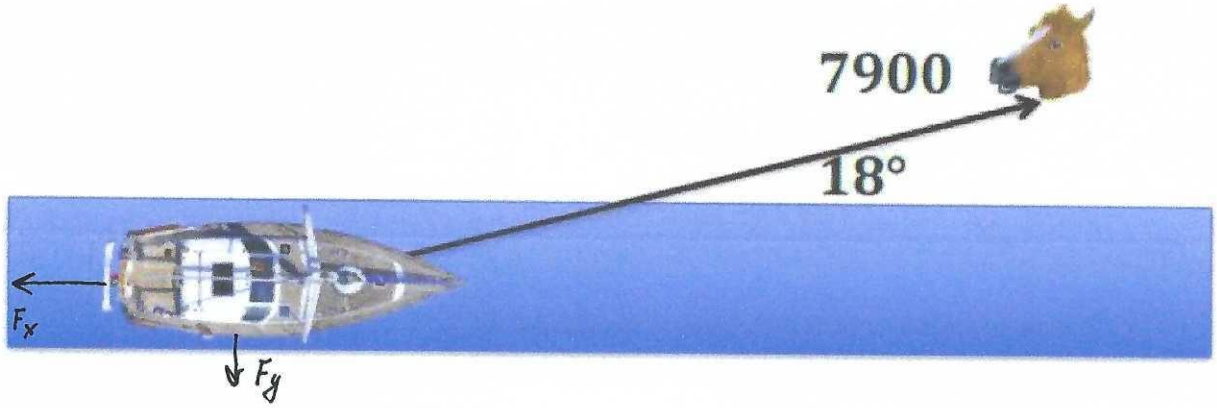
$mg - N = ma$

$N = mg - ma$

$= 50(9.8 - 1.5) = 415\ N$

24.

The horse pulls with a force of 7900 N. The angle between the rope and the canal is 18°. The horse is on the same vertical level as the boat so there is no vertical component to the force. The motion of the boat is straight down the canal.



The mass of the barge is 9500 kg and the magnitude of its acceleration is 0.12 m/s^2. Calculate the drag force exerted by the water on the barge. (Do not include the buoyancy force as this is not a drag force.) Give both magnitude and the direction. Hint: the drag force from the water does not point in the same direction as the rope! Show your working. (9 marks)

$7900\cos 18° - F_x = 9500 \times 0.12$

$F_x = 7900\cos 18° - 9500 \times 0.12$

$= 6373\ N$

$7900\sin 18° - F_y = 0$

$F_y = 7900\sin 18°$

$= 2441\ N$

$F = \sqrt{F_x^2 + F_y^2} = \sqrt{6373^2 + 2441^2} = 6829\ N$

$\tan\theta = \frac{F_y}{F_x}$ $\theta = \tan^{-1}\left(\frac{2441}{6373}\right) = 21°$