Answers to Coursebook questions – Chapter 2.4

1 **a** 30 N to the right.

b 6 N to the right.

c 8 N to the left.

d 15 N to the right.

e 10 N down.

f 20 N up.

2 The horizontal components cancel out, leaving a net force of $2\times 20\times \sin 45^\circ = 28\text{ N}$ in the up direction.

3 Taking components we find: for the *F* force, $F_x = F\cos\theta$, $F_y = F\sin\theta$. For the 12 N force, $12_x = 12\times\cos 40^\circ = 9.19\text{ N}$ along the negative *x*-axis and $12_y = 12\times\sin 40^\circ = 7.71\text{ N}$ along the positive *y*-axis. For the 15 N force, $15_x = 15\times\cos 70^\circ = 5.13\text{ N}$ along the positive *x*-axis and $15_y = 15\times\sin 70^\circ = 14.1\text{ N}$ along the negative *y*-axis. Then the net force N has components $N_x = F_x - 9.19 + 5.13$ and $N_y = F_y + 7.71 - 14.1$. These are zero when $F_x = 4.06\text{ N}$ and $F_y = 6.39\text{ N}$. The force *F* is thus $F = \sqrt{4.06^2 + 6.39^2} = 7.57 \approx 7.6\text{ N}$ and $\theta = \tan^{-1}\dfrac{F_y}{F_x} = 58^\circ$.

4 Because there would be no vertical force to cancel the weight of the block.

5 **a** Since the string is being pulled slowly, we have equilibrium until one of the strings breaks. If the lower string is being pulled with force *F*, then the tension in the lower string will be *F* and the tension in the upper string will be *T*, where $T = mg + F$. The tension in the upper string is thus greater and will reach breaking point first.

b If the lower string is pulled down very abruptly, the inertia of the block will keep it momentarily motionless, and so the tension in the lower string will reach a high value before the upper one does. Hence it will break.

6 The components of the 5.00 N force are $5_x = 5.00\times\cos 20^\circ = 4.698\text{ N}$ and $5_x = 5.00\times\sin 20^\circ = 1.710\text{ N}$. The net force thus has components: $N_x = -5.302\text{ N}$ and $N_y = 1.710\text{ N}$. The net force is thus $N = \sqrt{5.302^2 + 1.710^2} = 5.57\text{ N}$ and $\theta = \tan^{-1}\dfrac{N_y}{N_x} = \tan^{-1}\dfrac{1.710}{-5.302} = -17.9^\circ$. But the force is in the second quadrant and so the angle with the positive x – axis is $180^\circ - 17.9^\circ = 162^\circ$.

7 $N = \sqrt{2.45^2 + 4.23^2} = 4.89\text{ N}$.

8 The weight of the block is approx. $W = 12.5 \times 10 = 125\text{ N}$. The force F is the tension in the single string of the problem, and two tensions are pulling up on the mass (one from each side). Hence, $2F = W \Rightarrow F = 62.5\text{ N}$.

9 The tension in the string will be equal to the frictional force of 12 N. In turn, this tension must equal the hanging weight. Hence the mass is approx. 1.2 kg.

10 The tension T_3 equals the weight of the hanging block, i.e. $T_3 = 50.0\text{ N}$. We need to get the components of T_2: $T_{2x} = T_2 \cos 45^\circ = \dfrac{T_2\sqrt{2}}{2}$ and $T_{2y} = T_2 \sin 45^\circ = \dfrac{T_2\sqrt{2}}{2}$. We have equilibrium for:

$$\frac{T_2\sqrt{2}}{2} = T_1 \quad \text{and} \quad \frac{T_2\sqrt{2}}{2} = T_3$$

i.e. $\dfrac{T_2\sqrt{2}}{2} = 50.0 \Rightarrow T_2 = 70.7\text{ N}$ and so $T_1 = \dfrac{70.7 \times \sqrt{2}}{2} = 50.0\text{ N}$.

11 Equilibrium in the horizontal direction implies that: $F\cos 45^\circ = f$ and $F\sin 45^\circ + N = Mg$. These two equations simplify to:

$$F\cos 45^\circ = 0.4N$$
$$F\sin 45^\circ = Mg - N$$

Eliminating N gives

$$F\cos 45^\circ = 0.4(Mg - F\sin 45^\circ) \Rightarrow F = \frac{0.4Mg}{\cos 45^\circ + 0.4 \times \sin 45^\circ} = 20.2\text{ N}.$$

In this case the equations change to: $F\cos 45^\circ = f$ and $F\sin 45^\circ + Mg = N$. These two equations simplify to:

$$F\cos 45^\circ = 0.4N$$
$$F\sin 45^\circ = N - Mg$$

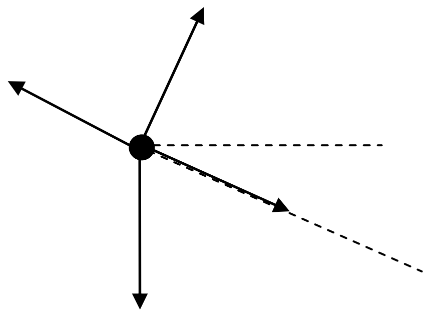
Eliminating N gives $F\cos 45^\circ = 0.4(F\sin 45^\circ + Mg) \Rightarrow F = \dfrac{0.4Mg}{\cos 45^\circ - 0.4 \times \sin 45^\circ} = 47.1\text{ N}$.

Note: This question ignores torques that are not in balance and hence the rod, as soon as the force is applied, would tilt and the angle would change. The problem shows that it is easier to pull something rather than push it.

12 We have that $F\cos 30^\circ = 1163 \Rightarrow F = 1343\,\text{N}$.

13 **a** It equals the weight of the plane, 25 980 N.

b A force diagram looks something like the following, where the lift force is normal to the direction of motion and a resistance force is opposite to the direction of motion. The engine force is in the direction of motion.



From the equilibrium in the direction normal to the direction of motion we find $L = Mg\cos 10^\circ = 25585\,\text{N}$.

14 The component of the weight down the plane is $Mg\sin\theta$, and for equilibrium this is also the tension in the string. To have equilibrium for the hanging mass, its weight must equal the tension and so $Mg\sin\theta = mg$. Hence $\theta = \sin^{-1}\dfrac{m}{M}$.

15 Let the extension of each spring be *x*. Then the tension in each spring is $T = kx$. Taking components of the tension forces we see that the horizontal components will cancel and the vertical ones give a total of $2T\cos\theta = 2kx\cos\theta$.

Hence, $2kx\sin\theta = mg \Rightarrow x = \dfrac{mg}{2k\cos\theta}$.

