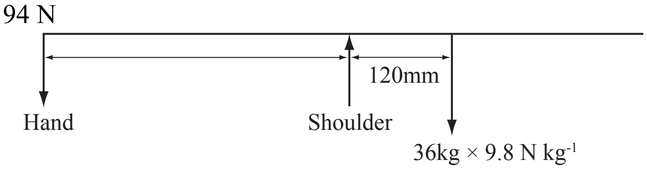
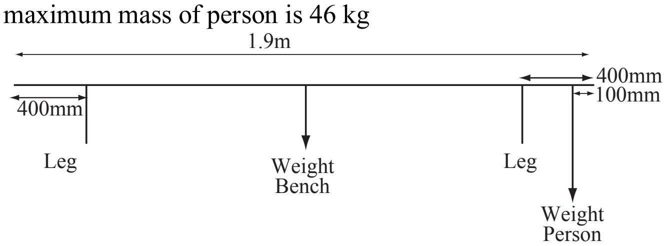
Motion and Forces in a Gravitational Field: Set **5**

Set	Problem	Solution
5	1	m N – is a product of two units, metres and force. mN – is milliNewtons
	2	Torque = force × perpendicular distance Torque = 160 N × 0.75 m Torque = 120 N m
	3	$force = \frac{torque}{perpendicular\ distance} = \frac{88\ N\ m}{0.4\ m} = 220$ N
	4	In a bus or truck more turning force (torque) is needed to turn the wheels. The same force on a larger steering wheel will provide a greater torque than the same force on a smaller steering wheel. Racing cars have a smaller steering wheel, a smaller movement of the steering wheel causes a greater amount of turning in the car, but a larger force is needed.
	5	Leaning forward ensures that the centre of mass of hiker + backpack is over the feet. Otherwise the pack may cause the hiker to fall backwards.
	6a	Amanda's torque about pivot = 24 kg × 9.8 N kg^{-1} × 2.5 m = 590 N m Father's torque about pivot point = 60 kg × 9.8 N kg^{-1} × 1.6 m = 940 N m
	6b	Combined torque of Ben & Amanda = 940 N m Torque of B & A = 590 N m + (W_B× 2.0 m) Torque B = 940 N m – 590 N m = 350 N m 350 N m /2.0 m = 175 N (Ben's weight) 175 N / 9.8 N kg^{-1} = 18 kg
	7	With a smaller radius the distance from the axle to the road is reduced and a greater force is transferred to the road. Greater acceleration is achieved but a lower top speed.
	8a	Use shoulder as pivot point 450 × 10^{-3} m × F =120× 10^{-3} m × 36 kg × 9.8 N kg^{-1} F = 94 N 
	8b	Use centre of mass of pipe as pivot point C.W.M. = A.C.W.M. 120 × 10^{-3} m × F = 94 N × 570 × 10^{-3} m F = 447 N
	9	Use chair leg nearest the person as pivot point, chair will tip when turning force of person is greater than turning force due to weight of chair. F_{person} × 0.3 m = 25 kg × 9.8 N kg^{-1} × 0.55 N F_{person} = 450 N Therefore maximum mass of person is 46 kg 
	10a	If platform is not moving then net force is 0 N. Upwards force = Downwards force 320N + 590 N = 280 N + John John = 630 N

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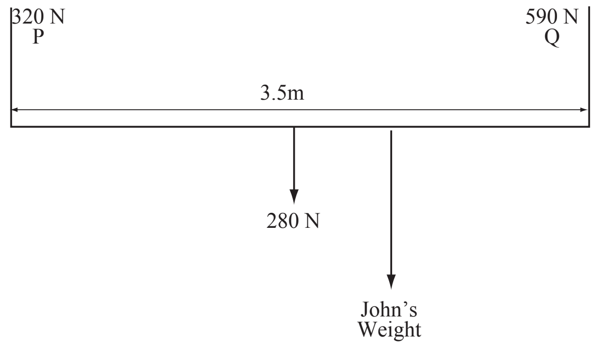
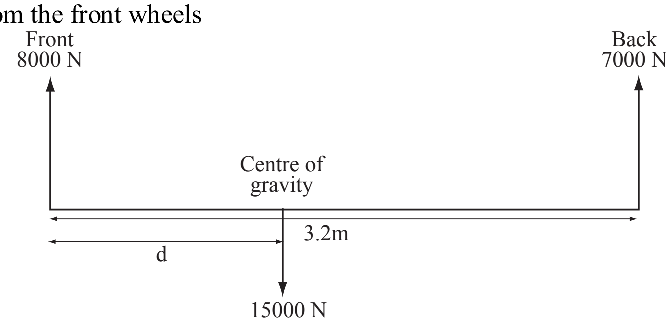
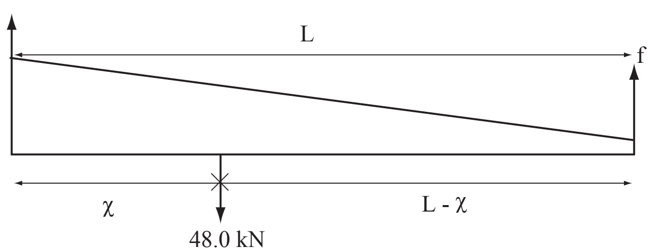
5	10b)	Take moments about P C.W.M. = A.C.W.M. (280 N × 1.75 m) + (630 N × d) = 590 N × 3.5 m d = 2.5 m from P, which is equal to 0.75 m from the centre towards Q 
	11	Use front wheels as pivot point C.W.M. = A.C.W.M. 15000 N × d = 7000 N × 3.2 d = 1.5 m 1.5 m from the front wheels 
	12a	If maximum force was needed then load at heavier end = 30 kN 48 kN – 30 kN = 18 kN 
	12b	Length of whole trunk is L. Centre of mass is distance x from heavy end. Take moments about light end. C.W.M. = A.C.W.M. 48,0000 × (L – x) = 30,000 × L 48,0000L – 48,0000x = 30,0000 L x = 0.375 L centre of mass is 0.375L from heavy end.
	13	When the car is turning to the left there is a large frictional force applied at the base of the right hand wheel. The friction creates a clockwise torque about the centre of the wheel (where it is attached to the axle) tending to roll the car. The weight force of the car creates an anticlockwise torque to stabilise the car. For stability the anticlockwise torque must be greater than the clockwise torque when cornering. This is done by reducing the distance between the frictional force and the pivot point and increasing the distance between the weight force and the pivot point. So the centre of mass is lowered and the wheel base is increased.

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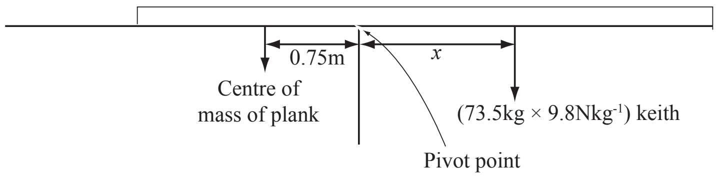
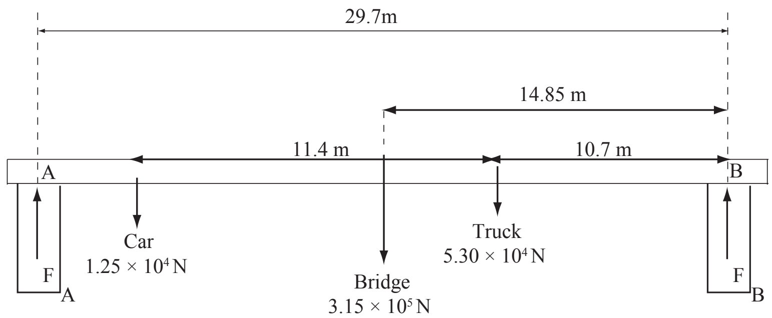
5	14a	Take moments about the end of the balcony C.W.M. = A.C.W.M. $73.5 \text{ kg} \times 9.8 \text{ N kg}^{-1} \times d = 37.5 \text{ kg} \times 9.8 \text{ N kg}^{-1} \times 0.75\text{m}$ d = 0. 383 mm from the balcony 
	14b	By decreasing the overhang of the plank the distance between the centre of mass and the end of the balcony is increased so the anticlockwise torque is greater. Or place heavy objects at the end of the plank to produce a greater anticlockwise torque.
	15	Weight of bridge and vehicles = 3.805×10^5 N Take moments about B C.W.M. = A.C.W.M. $F_A \times 29.7 \text{ m} = (1.25 \times 10^4 \text{ N} \times (11.4 \text{ m} + 10.7 \text{ m})) + (3.15 \times 10^5 \text{ N} \times 14.85 \text{ m}) + (5.3 \times 10^4 \text{ N} \times 10.7 \text{ m})$ $F_A = 1.86 \times 10^5$ N The bridge is in equilibrium so total of up forces = total of down forces $F_A + F_B = 3.805 \times 10^5$ N $1.86 \times 10^5 \text{ N} + F_B = 3.805 \times 10^5$ N $F_B = 1.95 \times 10^5$ N 
	16	When the students bend over their centre of mass moves forwards so that their weight creates a moment about their toes with a moment arm length equal to the distance between their toes and their centre of mass. Consequently they fall foward. If the students move away from the wall then their legs are angled backwards as their hips move back so their centre of mass stays over their feet.
	17	Your arms do not have the same strength as your legs. Also when you stand on your feet the tendons in the back of your lower leg adjust to counteract unbalanced torques produced as your centre of mass moves slightly, there are no equivalent tendons in your arms that can do this (humans did not evolve to walk on their hands!)
	18	When you are standing still your centre of mass acts through a vertical line about ½ way between your feet. When you walk your weight force creates an unbalanced turning moment about the foot still on the ground, moving our arms helps to lessen this effect, folding our arms prevents us from doing this.

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5	19	Leaning forward helps to keep the hurdlers centre of mass as low as possible while clearing the hurdle so that less energy is used in raising the centre of mass over the hurdle.
	20	Total upwards force = total downwards force 110 N + 260 N = 294 N + S S = 76 N S = 7.76 kg Take moments about wire 1. C.W.M. = A.C.W.M. (294 N × 1.5 m) + (76 N × 3 m) = 260 N × d d = 2.57 m from wire 1.
	21	If the planks are not to tip then the centre of mass of the combined planks should be on the pivot point. There will be the same weight either side of the pivot point. Since both planks are identical then if ¾ of the lower plank on the table, ¾ of the upper plank can be over the edge of the table. ¾ of 80cm is 60cm.