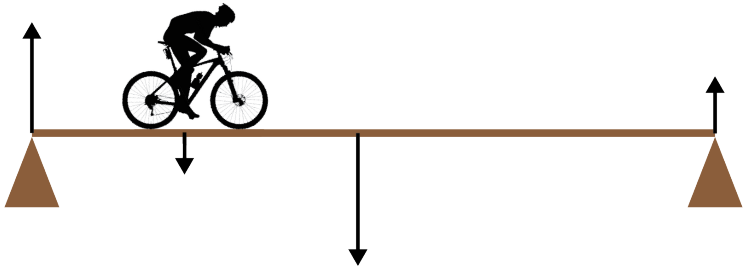
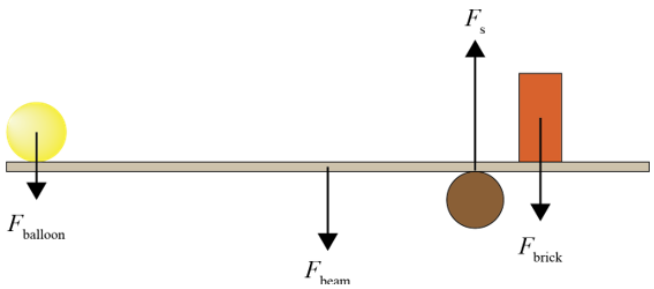
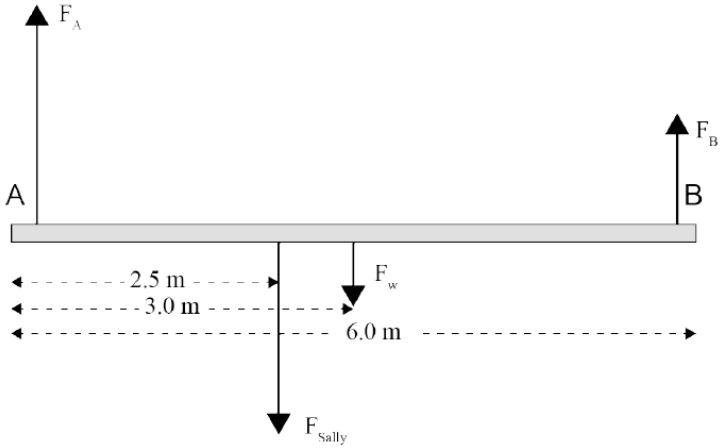
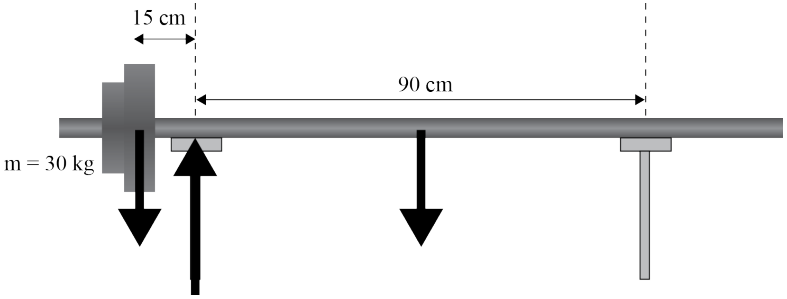
Level 2 Physics: Mechanics – Equilibrium Answers

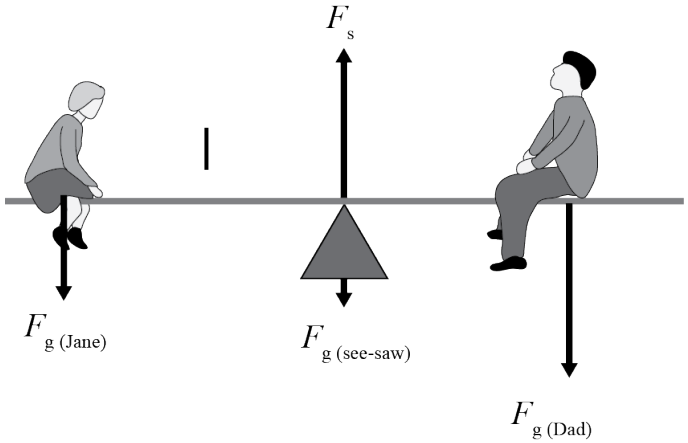
Question	Evidence	Achievement	Merit	Excellence
2022(3) (c)	Taking moments about end A $0 + F_b \times 0.3 = 1 \times 3 \times 9.8$ so $F_b = 98$ N upwards The down force = the up force $F_a + 3 \times 9.8 = 98$ so $F_a = 68.6$ N downwards	Correct idea of torques, at least one calculated **with** pivot identified.	Correct answer.	
2021(3) (b)	No net forces and no net torques.	BOTH correct.		
(c)		FOUR arrows correct direction and placement.	FOUR arrows correct direction and placement with some attempt at relative lengths.	
(d)	Weight force of bridge = 700 x 9.8 = 6860 N. Weight of person + bike = 833 N Taking moments about B: $4F_a = (85 \times 9.8 \times 3) + (700 \times 9.8 \times 2)$ $F_a = 4055 = 4100$ N upward forces = downward forces $F_a + F_b = (85 \times 9.8) + (700 \times 9.8)$ $F_a + F_b = 7693$ N $F_b = 7693 - F_a = 3638 = 3600$ N	ONE correct torque.	Correct solution except for one error.	Found both support forces.

2020(3) (a)	All torques and all forces are balanced	Correct answer.		
(b)	13 x 30 000 x 9.8 + 1600 x 9.8 x ***x*** = 26 x 160 000 3 8222 000 + 15 680 ***x*** = 4 160 000 *x* = 21.6 m from support force A.	A correct torque.	Correct distance.	
2019(2) (d)(i) (ii)	At least 4 forces correctly labelled. $T_{ac} = (588 \times 0.25) + (98 \times 0.75) + (588 \times 0.6) = 147 + 73.5 + 352.8 = 573.3$ N m $T_c = T_{ac}$ for bench to balance equilibrium. Force at A $= \frac{\text{Torque}_{ac}}{\text{distance}} = \frac{573.3}{1.5} = 382.2$ N. And F_b = sum of downward forces – F_a = 1274 – 382.2 = 891.8 N. Sum of forces = 0, and sum of torques = 0 (A only) The bench is uniform.	At least four forces labelled correctly OR Correct assumptions stated	Achieved AND Anticlockwise torque calculated accurately.	
2018(2) (a)		THREE of the forces correct with labels OR all four forces correct with 2 labels		

(b)	$\Sigma\tau_{AC} = \Sigma\tau_C$ $F_{holder}\, d_{holder} + F_{beam}\, d_{beam} = F_{brick}\, m_{brick}$ $[(0.190 \times 9.8) \times 0.8] + [(0.3 \times 9.8) \times 0.25]$ $= [(m_{brick} \times 9.8) \times 0.07]$ $2.2246 = m_{brick} \times 0.686$ m_{brick} 3.24 kg = 3.2 kg	Calculation done but has not taken into account mass of the beam, so m_{brick} = 2.17 kg. OR one error	Correct answer and correct working.	
2017(3) (a)	All 4 forces are labelled correctly and have correct directions.  	At least 3 forces are labelled correctly.		
(b)(i) (ii)	The sum forces (in any direction) must be zero, and the sum of the torques (about any point) must be zero. total $\tau_C = F_{Sally}\, d_{Sally} + F_{plank}\, d_{plank}$ $= (40 \times 9.8 \times 2.5) + (5 \times 9.8 \times 3) = 1127$ N m	Both conditions of the equilibrium stated. OR Correct total torque. OR One condition stated AND one correct torque of the dancer or plank.	Both conditions of the equilibrium stated. AND Correct total torque.	

(c)(i) (ii)	total τ_C = total τ_{anti} = 1127 N m $F_B \times 6 = (40 \times 9.8 \times 2.5) + (5 \times 9.8 \times 3)$ [From Q3(b)(ii)] $F_B \times 6 = 1127$ $F_B =$ 188 N Total downward force = (40 + 5) 9.8 = 441 $F_A = 441 - 188 = 253$ N The alternative method where torques are calculated about end B [$\tau = Fd \rightarrow 1519 = F \times 6$], is acceptable. The total downwards forces ($F_w + F_{Sally}$) remains constant and the total upwards forces ($F_A + F_B$) also remains constant (equal and opposite). As Sally moves towards point B, the upwards force Alf provides decreases (and the force Bert provides increases), due to net torque remaining zero.	Correct substitution for total clockwise torque or total anticlockwise torque. OR Correct description for (c)(ii).	(c) (i) correct OR (c) (ii) correct	Correct answer. AND Correct explanation.
2016(3) (a)	$\tau = F \times d$ $= 50 \times 9.8 \times 3.0 = 1470$ N m = 1500 N m	Correct answer with correct units.		
(b)	Force at support A must be downwards so the torque by the Force at A is in an opposite direction (anticlockwise) to the total clockwise torque created by Sarah and the weight force of the board.	Correct direction (with an attempt to give some correct explanation).	Correct answer with correct reasoning.	
2015(4) (d)	Taking B as pivot (or moments about B), $F_A \times 1.5 = (7.4 \times 9.8 \times 0.45) + (37 \times 9.8 \times 0.75)$ $F_A \times 1.5 = 32.6 + 271.95$ $F_A = \frac{304.55}{1.5} = 203$ N $F_A = 200$ N	Correct substitution for one direction of torque about specified end. AND correct torques.	One mistake. E.g. final answer for F_B (232 N) instead of F_A	All correct.

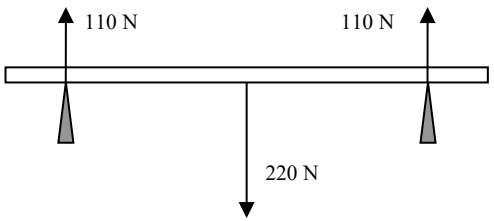
2014(2) (b)	 $\tau_c = \tau_{ac}$ $(m \times 9.8) \times 0.45 = (30 \times 9.8) \times 0.15$ $m = 10\ \text{kg}$ $W = 98\ \text{N}$	Correct *labelled* diagram OR correct mathematical solution: (Either *m* = 10 kg OR *W* = 98 N as long as unit is correct.)	Correct *labelled* diagram AND correct mathematical solution.	

Question	Achievement	Merit	Excellence
2013(2) (a)	 All four vectors correct without labels. OR three correct vectors labelled.	All four vectors correctly drawn and labelled. ***F_s* must be larger**.	
(b)	$(30 \times 9.8 \times 1.5) + F \times 1.5$ $= 72 \times 9.8 \times 1.5$ **441** $\times F \times 1.5 =$ **1058** OR (**450** $+F \times 1.5 =$**1080**) OR **294** $+F_s =$ **705.6** OR Taking moments / calculating torques wrt to Dad's end: $(30 \times 9.8 \times 3.0) + (60 \times 9.8 \times 1.5) - (F_S \times 1.5) = 0$ where F_S is the support force at the pivot when Dad's end is on the ground 882 + 882 = 1.5 F_S hence F_S = 1764 ÷ 1.5 = **1176 N**	$F \times 1.5$ $= 72 \times 9.8 \times 1.5 - 30 \times 9.8 \times 1.5$ $F \times 1.5 = 1058.4 - 441.0$ $F \times 1.5 = 617.4$ OR ($F \times 1.5 = 630$) OR Total F_{UP} = total F_{DOWN} $F_S + F_{GROUND}$ $= (30 \times 9.8) + (60 \times 9.8) + (72 \times 9.8)$ = 294 + 588 + 706 = **1588 N**	$F = \frac{617.4}{1.5} = 411.6\ \text{N}$ OR (F = 420 N) OR Hence F_{GROUND} = 1588 – 1176 = **412 N**

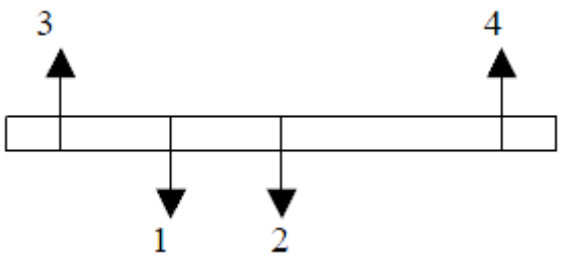
(c)	TWO of: • The only unbalanced force acting on the ball is the force of gravity. • Gravity acts downwards. • This unbalanced force causes the ball to decelerate or accelerate downwards. • Velocity at the top is zero.	The only unbalanced force acting on the ball is **gravity**, which acts downwards. This causes the ball to **decelerate** or accelerate downwards. Hence the ball slows down to **a stop** when it reached maximum height.	
2012(2) (a)	$\tau_c = \tau_{ac}$ $(2 \times 55 \times 9.8) + (0.5 \times 210) = F \times 3$	1183 = F × 3 F = 394.3 = 394 N	F= 394 N Direction = up
(b)	390 (2 sig figs) AND Same as the least accurate data.		

Question	Evidence	Achievement	Merit	Excellence
2011(2) (a)	At equilibrium, Σclockwise torques = Σanticlockwise torques Taking A as pivot, $(5 \times 72 \times 9.8) + (12.5 \times 760 \times 9.8) = F_B \times 25$ $F_B = 96\ 628/25$ $\Rightarrow F_B = 3865.12 = 3900$ N $F_A = (705.6 + 7448 - 3865.12)$ $F_A = 4288$ N $F_A = 4300$ N	Correct answer to sum of downward torques = 96 628 Nm (or 10721 Nm) (Must use weight force for calculation not just mass). *Accept 98 600 Nm if using $g = 10\text{ms}^{-2}$	Correct answer to support force at either A or B. Accept 3 944 N for F_B and 4376 N for F_A ($g = 10\text{ms}^{-2}$).	Correct answer to support force at both A and B.
(b)	2 s.f. for both FA and FB The lowest number of sf in the question is 5.0 which is 2 s.f. The final answer cannot be any more accurate than the least accurate piece of data in the question.	Correct rounding to 2 sf. OR Reason.	Correct rounding and reasoning.	

2010(5) (c)	The total force is zero and the total torque is zero.	One correct statement.	Both statements correct.	
(d)	$\tau_C = \tau_{AC}$ $W \times 1.5 + (539 \times 2) = 420 \times 3$ $W = \frac{1260 - 1078}{1.5} = 121\ \text{N}$ $m = \frac{W}{g} = \frac{121}{9.8} = 12.3\ \text{kg} = 12\ \text{kg}$ OR m = 10.6 kg (if used with g = 10 N kg^{-1})	Correct equation and substitution (line 2). Even though g cancels out, it must be included in the equation unless it is clearly stated that it cancels.	Correct answer for W =121 N OR If used g = 10 m s^{-2}, then W = 106.6 N OR Got one error in substitution but got rest of method correct.	Correct answer. Accept either 12.3 kg or 10.6 kg
2009(3) (a)	Sum of translational forces is zero. Sum of torques is zero.	One correct statement. **Accept total force up = total force down OR Anticlockwise torque = clockwise torque	Both statements correct (or words to that effect).	
(b)	(i) Fw = mg = 0.40 × 9.8 = 3.92 N (ii) Fw = mg = 0.20 × 9.8 = 1.96 N	Both correct including unit. *NA → *if they have used g = 10 ms^{-2}*		
(c)	$F \times 0.100 =$ $(0.20 \times 9.8 \times 0.250) + (0.40 \times 9.8 \times 0.300)$ $F = \frac{0.49 + 1.176}{0.100}$ $F = 16.67\ \text{N}$ **Consequential marking if they have used g=10 for this one as well in addition to (b).	Correct substitution.	Correct answer.	

2009(2) (i)	$\sin 37° = \frac{F_v}{1500}$ $\cos 53° = \frac{F_v}{1500}$ $F_v = 1500 \times \sin 37°$ $F_v = 1500 \times \cos 53°$ $F_v = 902.7$ N	Correct working.		
(j)	$\tau_C = \tau_{AC}$ $(F_t \times 3) + (343 \times 1.5) = 900 \times 3$ $3F_t + 514.5 = 2700$ $3F_t = 2185.5$ $F_t = 728.5$ N	Determines a correct torque.	Correct working and answer.	
2007(2) (a)	 Other suitable labels include: Weight, Force of gravity, support.	Arrows are of the correct size in relation to each other. **OR** Arrows are not to scale but have force values indicating their size.	Arrows are of the correct size in relation to each other and appropriately labelled.	

(b)	$3 \times F_A = (0.80 \times 750) + (1.5 \times 220) + (2.25 \times 600)$ $3 \times F_A = 600 + 330 + 1350$ $F_A = 2280 \div 3$ $\boldsymbol{F_A = 760}$ **N** **OR** $3 \times F_B = (0.75 \times 600) + (1.5 \times 220) + (2.20 \times 750)$ $3 \times F_B = 450 + 330 + 1650$ $F_B = 2430 \div 3$ $\boldsymbol{F_B = 810}$ **N** $\Sigma F = 0$ therefore $\boldsymbol{F_A = 760}$ **N**	States that clockwise and anticlockwise torques are equal. **OR** Calculate ANY correct torque.	Correct formula and substitution but incorrectly determines ONE distance **OR** forgets to include the torque due to the beam. **OR** Calc $\Sigma\tau_{ac}$ about B **OR** Calc $\Sigma\tau_c$ about A	[2]Correct answer
2006(1) (f)	$\tau_1 = 450 \times 0.50$ $\tau_1 = 225$ Nm $\tau_2 = 225$ Nm $F_2 \times 3.5 = 225$ $F_2 = 64$ N *OR* $F_1 d_1 = F_2 d_2$ $450 \times 0.50 = F \times 3.5$ $F = 64$ N	Calculates torque due to Steve ($\tau = 225$ Nm).	Correct working and answer.	

2004(3) (b)(i)		All four arrows shown, all pointing in the correct direction.	Achievement *plus* the weight of the beam is shown in the centre, Nadia's weight is in the correct position and support forces are shown at the supports.	
(b)(ii) (b)(ii)	550 N 900 N	Both answers correct		
(b)(iii)	$F_A \times 4.0 = 550 \times 3.0 + 900 \times 2.0$ $F_A \times 4.0 = 1650 + 1800 = 3450$ $F_A = \frac{3450}{4.0} = 862.5\ \text{N}$	Correct calculation of torque of either weight force about B.	Correct calculation of torques of both weight forces about B.	Correct answer
(b)(iv)	Since the beam is in equilibrium, the sum of the clockwise torques is equal to the sum of the anticlockwise torques about any chosen point.	Balanced torques *OR* the beam is in equilibrium.	Both statements correct	

The Mess that is NCEA Assessment Schedules….

Level 2 Physics: **AS 91171** replaced **AS 90255.**

In 90255, from **2003 to 2011**, there was an Evidence column with the correct answer and Achieved, Merit and Excellence columns explaining the required level of performance to get that grade. Each part of the question (row in the Assessment Schedule) contributed a single grade in either Criteria 1 (Explain stuff) or Criteria 2 (Solve stuff). From 2003 to 2008, the NCEA shaded columns that were not relevant to that question.

In 91171, from **2012 onwards**, the answers/required level of performance are now within the Achieved, Merit and Excellence columns. Each part of a question contributes to the overall Grade Score Marking of the question and there are no longer separate criteria. There is no shading anymore. At least their equation editor has stopped displaying random characters over the units.

And **in 2013**, with 91171, we still have no Evidence column with the correct answer and Achieved, Merit and Excellence columns explaining the required level of performance to get that part – even though the other two Level 2 Physics external examinations do!!

And now in **2014 - 2017**, we have the Evidence column back……