Level 2 Physics: Mechanics – Hooke's Law Answers

Question	Evidence	Achievement	Merit	Excellence
2020(3) (c)	$F = kx$ Double *m* means double the force, which means double *x*, as k is constant.	Double *m.*	Double *m* andfully justified.	
(d)(i) (ii)	$50\,000 = k \times 1.8$ $k = 27\,777.8$ $E = \frac{1}{2}kx^2 = \frac{1}{2} \times 27\,777.8 \times 1.8^2$ $= 45\,000$ J $E = \frac{1}{2}mv^2$ $45\,000 \text{ J} = \frac{1}{2} \times 1600v^2$ $v = 7.5 \text{ m s}^{-1}$ Energy is conserved. Assumes all the energy from the spring is transferred to the car.OR no energy lost to accelerating the spring.	k found OR Energy conserved.	*v* found OR *E* found and assumption stated.	Correct answer with assumption.

2019(1) (c)	Calculates E_k and relates this to E_p. $E_k = 0.5 \times 0.16 \times 22^2 = 38.72$ J Uses this value to calculate k. = 3441.77 (rounded to 3442 N m^{-1})	Correct first bullet point or second point based on incorrect value for E_p. OR Correct process but with either or both units unconverted.	Correct value for k	
2018(1) (a)	Spring constant $= k = \frac{F}{x} = \frac{4.9}{0.05} = 98 \text{ N m}^{-1}$ or equivalent using other values from table. Spring constant = gradient $= \frac{\text{rise}}{\text{run}} = \frac{29.4}{0.3} = 98 \text{ N m}^{-1}$	Correct working and answer using data table or graph. Accept 100 N m^{-1} if graph is used		
(c)	Method 1: If k = 98 N m^{-1} $E_p = \frac{1}{2} k x^2 = 0.5 \times 98 \times 0.58^2 = 16.48$ J Total = $16.48 \times 2 = 32.97$ J = 33 J Method 2: $W = Fd = F_{avg}d = \frac{F_{peak}}{2}d = \frac{57}{2} \times 0.58 = 16.53$ J Total $= 16.53 \times 2 = 33$ J	One energy value correct.	Both energy values correct. Accept carry error (CE) or poor rounding, using incorrectly calculated force from Q1(b) or spring constant from 1(a) with consistent working.	

(d)	The idea of conservation of energy so E_p to E_k. Assume no energy loss. And $E_k = ½mv^2$ etc OR $F = ma$, kinematic equation. To maximise speed, you need to either: Increase E_p by increasing extension linked to $E_p = ½kx^2$ OR $W = Fd$. Use a stiffer stretchy rubber linked to a higher k, so more E_p from $E_p = ½kx^2$. Decrease mass of balloon linked to $E_k = ½mv^2$, lower m, means higher v.	Stated E_p to E_k and in turn velocity. OR One correct answer to (ii), with explanation. OR Two correct descriptions for (ii) with no explanation.	Stated E_p to E_k and in turn velocity. AND One correct answer to (ii), with explanation. OR Two correct answers to (ii), with full explanation.	Stated E_p to E_k and in turn velocity. AND Two correct answers to (ii), with full explanation.
2017(2) (c)	Weight force on one spring $= \frac{540}{20} = 27$ N $k = \frac{F}{x} = \frac{27}{0.045} = 600 \text{ N m}^{-1}$ $E = \frac{1}{2} \times 600 \times 0.045 \times 0.045 = 0.61 \text{ J}$ Alternative answer: Energy stored = work done $= \frac{1}{2}Fd$ $\Delta E = \frac{1}{2} \times 27 \times 0.045 = 0.61 \text{ J}$	Correct spring constant calculated. OR Incorrect spring constant, but consequently correct energy value (12.1 J).	Correct spring constant. AND Correct energy value. OR Correct answer and working using ΔE.	

2016(3) (c)	$F = kx$ $k = \frac{F}{x} = \frac{50 \times 9.8}{0.05} = 9800\ \text{N m}^{-1}$	Incorrect answer due to mass used as opposed to correctly using (weight) force.	Correct answer.	
(d)	• $E_p = \frac{1}{2}kx^2 = \frac{1}{2} \times 9800 \times 0.25^2 = 306\ \text{J}$ • $E_k = E_p$ • $\frac{1}{2}mv^2 = 306\ \text{J}$ so $v = 3.5\ \text{m s}^{-1}$	Elastic potential energy is correctly calculated. OR Idea that the kinetic energy changes into elastic potential energy.	Elastic potential energy is correctly calculated. AND Idea that the kinetic energy changes into elastic potential energy.	Correct answer.
2015(3) (d)	$F = -kx \Rightarrow k = \frac{F}{x}$ $k = \frac{65 \times 9.8}{0.075} = 8493\ \text{N m}^{-1}$ $E_p = \frac{1}{2}kx^2 \Rightarrow \frac{1}{2} \times 8493 \times 0.075^2$ $E_p = 24\ \text{J}$ OR $E_p = \frac{1}{2}Fx \Rightarrow \frac{1}{2} \times 65 \times 9.8 \times 0.075$ $E_p = 24\ \text{J}$	Correct value of k. OR One error in calculation. (Allow carryover for k value.)	Correct answer.	

2014(1) (d)	$E_p = \frac{1}{2}kx^2$ $E_p = \frac{1}{2} \times 1200 \times 0.009^2$ $E_p = 0.0486$ J $E_p = E_K = 0.0486$ J $\frac{1}{2}mv^2 = 0.0486$ $v = 0.40 \text{ m s}^{-1}$ (Total) energy is conserved / elastic potential energy is converted into kinetic energy/no energy is lost from the system.	EITHER ONE correct mathematical step. OR Correct assumption statement	EITHER TWO correct mathematical steps. OR ONE correct mathematical step AND correct assumption statement.	TWO correct mathematical steps. AND Correct assumption statement.

Question	Achievement	Merit	Excellence
2013(3) (d)(i)	$E_p = \frac{1}{2}kx^2$ $E_p = \frac{1}{2} \times 78000 \times 0.15^2$ $E_p = 877.5\ \text{J}$ $E_p = 880\ \text{J}$		
2012(3) (c)	*F* = *mg* and *F* = k*x* 55 × 9.8 = k × 0.60	k = 898.3	$E = \frac{1}{2}kx^2$ $E = \frac{1}{2} \times 898.3 \times 0.60^2$ *E* = 160 J

Question	Evidence	Achievement	Merit	Excellence
2011(3) (d)	The area under the graph is a measure of the work done or energy stored. This is a triangle and so, the formula is ½ *F d*. (Or, could calculate $k = F/x$ and substitute into $F = ½ kx^2$.) The formula $W = F d$ can be used only if the force is constant or if *F* is the average force. In the case of a spring / web as the extension increases, force increases and is therefore not constant.	[1] Recognition that the area under graph is energy stored or work done. OR States use $E_p = ½ kx^2$	[1] The idea that force is not constant but is proportional to extension. OR States bullet point 2.	[1] Correct answer covering bullet points 2 and 3.
(e)	$k = \frac{F}{x} = \frac{0.003 \times 9.8}{0.065} = 0.45 \text{ N m}^{-1}$ $E_p = \frac{1}{2}kx^2 = \frac{1}{2} \times 0.45 \times 0.065^2$ $E_p = 9.5 \times 10^{-4} \text{ J}$	[2]Correct answer for *k*.	[2]Correct answer for elastic potential energy.	
2010(5) (a)	$F = kx$ $k = \frac{F}{x}$ $k = \frac{539}{0.003} = 1.8 \times 10^5 \text{ N m}^{-1}$	[2]Correct except for unit conversion OR weight calculation. *If used mass = 55 kg and $x = 3$ then NA (two errors).	[2]Correct calculation and answer. *Ignore negative sign	
		[1]Correct unit.		

(b)	$E = \frac{1}{2}kx^2$ $E = \frac{1}{2} \times 1.8 \times 10^5 \times 0.003^2$ $E = 0.81$ J OR Solves using $E = \frac{1}{2}Fx$	[2]Correct answer.		
2009(3) (g)	Work done = energy stored $E_p = \frac{1}{2}kx^2$ $150 = 0.5 \times k \times 0.20^2$ $k_A = 7500$ Nm^{-1} $k_B = \frac{210}{0.5 \times 0.30^2}$ $k_B = 4667$ Nm^{-1} Spring A is stiffer as it has a higher value of *k*.	[2]Recognition that work done is energy stored. OR E_p=1/2 kx^2	[2]Correct answer to the spring constant of either one spring.	[2]Both spring constants correct AND statement of which spring is stiffer with reason.
2008(2) (l)	$k = \frac{F}{x} = \frac{95}{0.01} = 9\ 500$ N m^{-1} $E = ½ kx^2$ $E = ½ \times 9\ 500 \times 0.01^2$ $E = 0.475$ J	[2]Determines E_P using incorrect unit (full working must be shown).	[2]Correct working and determines spring constant.	[2]Correct working and answer.

2007(4) (a)	$x = 72 - 51 = 21$ cm $= 0.21$ m $F = 0.400 \times 10 = 4.0$ N $k = 4.0 \div 0.21 = 19$ N m^{-1}	[2]Calculates k using either cm (0.19048) or g (19 048). OR Uses correct units but takes length as extension (5.56).	[2]Correct answer.	
	N m^{-1} (or kg s^{-2}) DO NOT ACCEPT **lower case n for newtons.** *(Please Note: As with every International System of Units (SI) unit whose name is derived from the proper name of a person, the first letter of its symbol is upper case (N). However, when an SI unit is spelled out in English, it should always begin with a lower case letter (newton), except in a situation where any word in that position would be capitalized, such as at the beginning of a sentence or in capitalized material such as a title. Note that "degree Celsius" conforms to this rule because the "d" is lowercase. - Based on The International System of Units, section 5.2 so we do not know why this says DO NOT ACCEPT lower case for n above - NoBrainTooSmall).*	[1]Correct unit.		

(b)	m= 0.400 + 0.300 = 0.700 F = 0.700 × 10 = 7.00 N k = 19.0 N m^{-1} $x = F / k$ = 7.00 / 19.0 = 0.368 m $E_p = ½ kx^2$ = 0.5 × 19.0 × 0.368^2 = 1.29 J	[2]Calculates new extension.	[2]Correct working and answer.	
(c)	A spring with double the spring constant for the same weight force would mean half the extension as $F = kx$. As $E_P \propto k$, E_P doubles when k doubles for the same extension. As $E_P \propto x^2$ it decreases by four when x is halved for the same spring constant. Overall a spring with double the spring constant for the same weight force would mean half the extension and hence half the E_p.	[1]Has identified that extension and/or energy stored has decreased.	[1]Has qualitatively **described and explained** the effect of a higher spring constant on extension **OR** energy stored for **the same weight force**.	[1]Has **quantitatively** described AND explained the effect on BOTH the extension **AND** energy stored with a greater spring constant for **the same weight force**.
2005(1) (h)(i)	Weight = 357 × 10 = 3570 N $F = \frac{3570}{4} = 892.5$ N $x = \frac{F}{k} = \frac{892.5}{2.26 \times 10^4} = 0.0395$ m	[2]Correct approach **But:** weight not calculated **AND** does not divide by 4.	[2]Correct approach but weight not divided by 4 **OR** calculation done using mass but correctly	[2]Correct answer.

(h)(ii)	$E_p = \frac{1}{2}kx^2 = \frac{1}{2} \times 2.26 \times 10^4 \times 0.12^2$ $= 162.72 \text{ J} = 160 \text{ J}$	[2]Correct answer		

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. – Sorry not all the 2004 answers are here.

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……