Pearson Edexcel

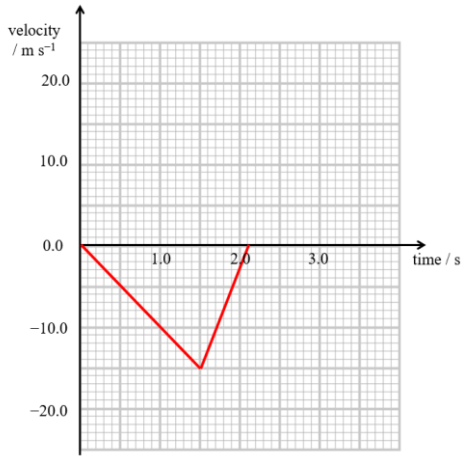
Mark Scheme (Final)

Summer 2023

Pearson Edexcel International Advanced Subsidiary Level In Physics (WPH11)
Paper 01
Unit 1: Mechanics and Materials

Question Number	Answer	Mark
1	**D is the correct answer** A is incorrect because efficiency is not a vector quantity B is incorrect because energy is not a vector quantity C is incorrect because power is not a vector quantity	**1**
2	**B is the correct answer** A is incorrect because the force is not acting in the direction of motion D is incorrect because tan 40° does not give parallel component of force C is incorrect because sin 40° does not give parallel component of force	**1**
3	**C is the correct answer** A is incorrect because shorter wire gives less extension B is incorrect because shorter and thicker wire gives less extension D is incorrect because thicker wire gives less extension	**1**
4	**B is the correct answer** Ais incorrect because area under graph is not a rectangle B is incorrect because work done is not the gradient of the graph C is incorrect because work done is not the gradient^{-1} of the graph	**1**
5	**A is the correct answer** B is incorrect because N3 pairs must have the same magnitude C is incorrect because N3 pairs must act at the same time D is incorrect because N3 pairs must be of the same type	**1**
6	**B is the correct answer** A is incorrect because the gradient gives a quarter of the acceleration C is incorrect because the gradient gives the wrong units D is incorrect because the gradient gives the wrong units	**1**
7	**D is the correct answer** A is incorrect because 15 is not the time taken B is incorrect because 2 ×15 is not the time taken C is incorrect because the displacement has not been doubled	**1**
8	**C is the correct answer** Because KE gained is GPE lost and the height lost is 20 m × sin 23°	**1**
9	**B is the correct answer** A is incorrect because viscosity decreases C is incorrect because viscosity decreases D is incorrect because weight of the ball bearing is constant	**1**
10	**D is the correct answer** A is incorrect because it would give a result in mm N^{-1} B is incorrect because two such springs in series would give an extension of 60 mm for a tension of 45 N, not 15 mm C is incorrect because it would give a result in mm N^{-1}	**1**

Question Number	Answer	Mark
11	Use of $v^2 = u^2 + 2\,a\,s$ with $u = 0$ **(1)** Substitutes $a = 0.38\,g$ **(1)** $\frac{v_M}{v_E} = 0.62$ **(1)** Example calculation $v_M{}^2 = 0 + 2 \times 0.38\,g\,\,s$ $v_E{}^2 = 0 + 2 \times g\,\,s$ $\left(\frac{v_M}{v_E}\right)^2 = \frac{0.38gs}{gs} = 0.38$ $\frac{v_M}{v_E} = \sqrt{0.38} = 0.62$	**3**
	Total for question 11	**3**

Question Number	Answer	Mark
12(a)(i)	(Initial) gradient = 0 **Or** Tangent horizontal (at $t = 0$) **(1)**	**1**
12(a)(ii)	**EITHER** Draws tangent at (1.5, 0.0) **(1)** (−)14 ± 1 m s^{-1} by graphical method **(1)** **OR** *suvat* method using quantities read from the graph and/or $a = \pm g$. **(1)** Correct answer from *suvat* calculation **(1)**	**2**
12(b)	Straight line from 0 to (1.5, − [magnitude from (a)(ii)]) **(1)** Second straight line from end of first line to (2.1, 0.0) **(1)** [Ignore lines beyond 2.1 s] 	**2**
	Total for question 12	**5**

Question Number	Answer	Mark
13(a)	Use of $E_k = ½ m v^2$ **(1)** $E_k = 2.1 \times 10^9$ (J) **(1)** Example calculation $E_k = 0.5 \times 7.2 \times 10^5$ kg $\times$ (76 m s^{-1})^2 = 2.08×10^9 J	**2**
13(b)	Use of $P = W / t$ **(1)** $D = 8.0 \times 10^8$ J (ecf from (a)) **(1)** Example calculation $W = 16 \times 10^6$ W $\times$ 180 s = 2.9×10^9 J $D = 2.9 \times 10^9$ J – 2.1×10^9 J = 8.0×10^8 J	**2**
	Total for question 13	**4**

Question Number	Answer	Mark
14	Resolves horizontal and vertical component of velocity **(1)** Use of $s = u t + ½ a t^2$ with $a = -g$ and $u = u_v$ **(1)** Use of $s = u t + ½ a t^2$ with $a = 0$ and $u = u_h$ **(1)** Horizontal distance = 130 m **(1)** Example calculation $u_v = 37$ m s^{-1} $\times$ sin 53° = 29.5 m s^{-1} $t = 2 \times 29.5$ m s^{-1} $\div$ 9.81 = 6.02 s $u_h = 37$ m s^{-1} $\times$ cos 53° = 22.3 m s^{-1} $s_h = 22.3$ m s^{-1} $\times$ 6.02 s = 134.1 m	**4**
	Total for question 14	**4**

Question Number	Answer		Mark
15(a)	Total momentum is conserved (because no external forces act) **Or** Total momentum before is equal to total momentum after (because no external forces act) **Or** Momentum of system is conserved (because no external forces act)	**(1)**	
	Total/system/initial momentum is zero	**(1)**	
	(Final momentum of machine is not zero because) final ball momentum is not zero **Or** Machine and ball have (equal but) opposite momenta	**(1)**	**3**
15(b)	Use of $p = mv$	**(1)**	
	Use of conservation of momentum	**(1)**	
	Velocity of machine = (−)0.087 m s^{-1}	**(1)**	**3**
	Example calculation 2.9 kg × v + 0.056 kg × 4.5 m s^{-1} = 0 v = −0.252 m kg s^{-1} ÷ 2.9 kg = −0.0869 m s^{-1}		
	Total for question 15		**6**

Question Number	Answer	Mark
16(a)	Flow (around sphere must be) laminar **Or** Flow (around sphere is) not turbulent **(1)**	**1**
16(b)(i)	Use of upthrust = weight of displaced fluid **(1)** $U = 5.2 \times 10^{-7}$ (N) **(1)** Example calculation $U = 5.3 \times 10^{-11}\ m^3 \times 998\ kg\ m^{-3} \times 9.81\ N\ kg^{-1}$ $= 5.19 \times 10^{-7}$ N	**2**
16(b)(ii)	Use of $V = \frac{4}{3}\pi r^3$ **(1)** Use of $F = 6\pi\eta r v$ **(1)** $F = 1.5 \times 10^{-7}$ N **Or** Required $v = 0.12\ m\ s^{-1}$ **Or** Required $V = 2.4 \times 10^{-9}\ m^3$ **Or** Required $r = 8.3 \times 10^{-4}$ m **and** $r = 2.3 \times 10^{-4}$ m **Or** Required $\eta = 3.4 \times 10^{-3}$ Pa s **(1)** Valid conclusion by comparison of relevant student values (ecf from (b)(i)) **(1)** Example calculation $5.3 \times 10^{-11}\ m^3 = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11}\ m^3}{4\pi}} = 2.33 \times 10^{-4}$ m If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4}\ Pa\ s \times 2.33 \times 10^{-4}\ m \times 3.50 \times 10^{-2}\ m\ s^{-1}$ $= 1.46 \times 10^{-7}\ N \neq 5.19 \times 10^{-7}\ N$ $\therefore$ Stokes' law does not apply	**4**
	Total for question 16	**7**

Question Number	Answer		Mark
17(a)(i)	Equates horizontal component with force from current	**(1)**	
	F = 480 (N)	**(1)**	**2**
	Example calculation F sin 33° = 260 N F = 260 N ÷ sin 33° = 477 N		
17(a)(ii)	Resolves vertical component of F	**(1)**	
	Equates vertical forces	**(1)**	
	Weight of buoy = 2500 N (ecf from (a)(i))	**(1)**	**3**
	Example calculation 477 N cos 33° = 400 N 400 N + Weight of buoy = 2.9×10^3 N Weight of buoy = 2900 N − 400 N = 2500 N		
17(b)	**EITHER** Horizontal component of F increases (to maintain equilibrium) **and** Vertical component of F remains the same (because vertical forces do not change, upthrust and weight are constant)	**(1)**	
	$F^2 = F_h^2 + F_v^2$ so F increases [dependent on MP1]	**(1)**	
	tan $\theta = F_h/F_v$ so θ increases [dependent on MP1]	**(1)**	
	OR Horizontal component of F increases (to maintain equilibrium) **and** Vertical component of F remains the same (because vertical forces do not change, upthrust and weight are constant)	**(1)**	
	$F^2 = F_h^2 + F_v^2$ so F increases [dependent on MP1] **Or** tan $\theta = F_h/F_v$ so θ increases [dependent on MP1]	**(1)**	
	F cos θ is constant so increase in either F or θ implies an increase in the other [dependent on MP2]	**(1)**	**3**
	Total for question 17		**8**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*18</td><td>
This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content and lines of reasoning.

<table>
<tr><th>IC points</th><th>IC mark</th><th>Max linkage mark available</th><th>Max final mark</th></tr>
<tr><td>6</td><td>4</td><td>2</td><td>6</td></tr>
<tr><td>5</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>4</td><td>3</td><td>1</td><td>4</td></tr>
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<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
<table>
<tr><th></th><th>Marks</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
Indicative content:

IC1 Balloon exerts a (backwards) force on the air

IC2 By N3 the air exerts an opposite (forwards) force on balloon

IC3 The forward force on the balloon is greater than resistive forces

IC4 By N2 the resultant force causes acceleration

IC5 As speed increases forces change until resistive force equals forward force

IC6 By N1 resultant force equals zero so acceleration equals zero (at maximum speed)
</td><td>6</td></tr>
<tr><td></td><td>Total for question 18</td><td>6</td></tr>
</table>

Question Number	Answer	Mark
19(a)	Use of $\Delta W = F\,\Delta x$ **or** $\Delta E_{grav} = mg\Delta h$ **(1)** Use of $P = W / t$ **(1)** Use of efficiency = useful power output / total power input **Or** Use of efficiency = useful energy output / total energy input **(1)** Total power input = 2.0×10^4 W **(1)** <u>Example of calculation</u> $\Delta W = 4.4 \times 10^4 \times 15$ m $= 6.6 \times 10^5$ J Output power = 6.6×10^5 J ÷ 70 s = 9.4×10^3 W Efficiency = $\frac{9.4\times10^3\ \text{W}}{\text{Total power input}} = 0.47$ Total power input = $\frac{9.4 \times 10^3\ W}{0.47} = 2.0 \times 10^4$ W	**4**
19(b)(i)	Total clockwise must balance total anticlockwise moment (about tower) **Or** Net/resultant/total moment (about tower) must be zero. **(1)** Total anticlockwise moment is due to counterweight **and** Total clockwise moment is due to sum of moment from beam and load **(1)** Increasing the distance of the load increases the (cw) moment (distance of CoG remains the same) **(1)** Distance of counterweight needs to be increased [dependent on MP3] **(1)**	**4**

19(b)(ii)	Use of moment = $F\,x$ **(1)** Position of centre of mass of beam identified **(1)** Use of principle of moments **(1)** Maximum distance of load = 15 m **Or, for load at 22 m …** CW moment =1.18×10^6 Nm **and** max ASW moment = 8.8×10^5 Nm **Or** Required distance of counterweight = 11 m **Or** Required counterweight = 1.5×10^5 N **Or** Maximum load = 3.0×10^4 N **Or** Required distance to CoG = 2.9 m **Or** Required weight of beam = 1.3×10^4 N **Or** Resultant moment = 3.0×10^5 Nm (cw) **(1)** Valid conclusion by comparison of relevant student values **(1)** <u>Example of calculation</u> For equilibrium: 3.0×10^4 N × 7.0 m + 4.4×10^4 N × x = 1.1×10^5 N × 8.0 m where x is the maximum distance of the load from the tower. x = (8.8×10^5 Nm − 2.1×10^5 Nm) ÷ 4.4×10^4 N = 6.7×10^5 Nm ÷ 4.4×10^4 N = 15.2 m 15.2 m < 22.0 m so crane would topple if load moved to end of beam	**5**
	Total for question 19	**13**

Question Number	Answer	Mark
20(a)	Stress (or strain) value at/beyond which a material/object undergoes a sudden or large plastic deformation **(1)**	**1**
20(b)(i)	The force/tension from/in the cable (on the actor) is greater than the weight of the actor **(1)** (So) there is a resultant/net/unbalanced force (upwards) **(1)**	**2**

20(b)(ii)	Use of $W = m\,g$ **(1)** Use of $\Sigma F = m\,a$ **(1)** Tension = 917 (N) **(1)** Example calculation $W = 77\text{ kg} \times 9.81\text{ N kg}^{-1} = 755\text{ N}$ $T - 755\text{ N} = 77\text{ kg} \times 2.1\text{ m s}^{-2}$ $T = 162\text{ N} + 755\text{ N} = 917\text{ N}$	**3**
20(b)(iii)	Use of $A = \pi r^2$ **(1)** Use of $\sigma = F \div A$ (ecf from (b)(ii)) **(1)** Allowed stress (15% yield stress of steel) = 3.8×10^7 Pa **and** $\sigma = 2.0 \times 10^7$ Pa **Or** $(15\%)^{-1}$ of cable stress = 1.3×10^8 Pa **Or** Max safe tension = 1.7×10^3 N **Or** Min safe diameter = 5.6×10^{-3} m **Or** Percentage of yield stress = 8% **Or** Max safe acceleration = 12.3 m s^{-2} **(1)** Valid conclusion by comparison of relevant student values **(1)** Example calculation $A = \frac{\pi d^2}{4} = \frac{\pi \times (7.6 \times 10^{-3}\text{m})^2}{4} = 4.54 \times 10^{-5}\text{ m}^2$ $\sigma = \frac{917\text{ N}}{4.54 \times 10^{-5}\text{m}^2} = 2.02 \times 10^7\text{ Pa}$ (show that value gives 2.03×10^7 Pa) $0.15 \times 2.5 \times 10^8\text{ Pa} = 3.75 \times 10^7\text{ Pa}$ $2.03 \times 10^7\text{ Pa} < 3.75 \times 10^7\text{ Pa}$ so it is safe.	**4**
20(c)	New cable has a greater cross sectional area, (but same breaking stress) so a greater force is required **(1)** Because new cable has smaller Young modulus, there is a greater strain for the same stress **(1)** So (at breaking stress) there will be a greater extension (because cables are the same length) [dependent on MP2] **Or** Smaller Young modulus implies greater extension (at breaking stress, because cables are the same length) [independent mark] **(1)** (And as) force and extension both increase, work done to break the new cable is greater than that for the original cable [independent mark] **(1)**	**4**
	Total for question 20	**14**