Work, Energy and Power Exam Questions (From OCR 4729)

Note: These questions are aimed at Year 1 students and so do not contain any exam questions that refer to the coefficient of friction μ. Refer to the Year 2 exam questions at the end of this sheet should you want to attempt such questions.

Q1, (Jun 2006, Q1)

mgh = 35 x 9.8 x 4	M1			
	A1			
mgh/t = 1372/10	M1		watch out for extras	
137 W	A1	4	or 0.137 kW	**4**

Q2, (Jun 2009, Q1)

$\frac{1}{2}\times75\times12^2$ or $\frac{1}{2}\times75\times3^2$ (either KE)	B1		M1	$12^2 = 3^2 + 2a \times 180$	
$75\times9.8\times40$ (PE)	B1		A1	$a = 0.375$ (3/8)	
$R\times180$ (change in energy = 24337)	B1		M1	$75 \times 9.8 \times \sin\theta - R = 75a$	
$\frac{1}{2}\times75\times12^2=\frac{1}{2}\times75\times3^2+75\times9.8\times40-R\times180$	M1		A1	$R = 135$	
$R = 135$ N	A1	**5**		(max 4 for no energy)	**5**

Q3, Jun 2015, Q1)

(i)	$D = 480/v$	B1	Use of $D = P/v$	
	$480/v - 60 = 0$	M1	Use of N2L with 2 terms to find v	
	$v = 8$ m s^{-1}	A1		
		[3]		
(ii)	600×14.2	B1	WD by cyclist (8520 J)	
	$\frac{1}{2}(80)(9.4^2 - 8^2)$	B1ft	ft v from (i); KE gained (974.4 J); may be implied in energy equation	
	$8520 = 974.4 + 60d$	M1	Attempt at energy equation with all terms	
	$d = 126$ m	A1	Exact 125.76	
		[4]		

Q4, (Jun 2016, Q1)

(i)	Driving force $= \frac{23000}{v}$	B1		
	$\frac{23000}{v} - 600 = 1400(0.3)$	M1	Attempt at N2L with 3 terms; allow D – 600 = 1400(0.3)	
	$v = 22.5\,\text{m s}^{-1}$	A1	$v = 22.54901...$; allow $^{1150}/_{51}$	
		[3]		
(ii)	$D - 600 - mg\sin 10 = 0$	M1	Attempt at N2L with three terms $(D = 2982.452998)$; g needed	
	$P = (\text{cv}(D))(12)$	M1	Use of $P = Dv$	
	$P = 35.8$ kW or 35800 W	A1	$P = 35789.43597$	
		[3]		

Q5, (Jan 2006, Q3)

(i)a	100 J	B1	1		
b	7500 Nm	B1	1		
(ii)	400cosα x 25 =7500 + 100	M1		sc N II gets M1A1only.This M1	
	√ for = a + b	A1√		for total M (a=0.08)&A1for α	
	α = 40.5	A1	3	or 0.707 rads	**5**

Q6, (Jan 2007, Q4)

(i)	$\frac{1}{2}x80x5^2$ or $\frac{1}{2}x80x2^2$ either KE	B1		1000/160	
	70 x 25	B1		1750	
	80x9.8x25sin20°	B1		6703.6	
	WD=$\frac{1}{2}x80x5^2$-$\frac{1}{2}x80x2^2$+70x25+80x9.8x25sin20°	M1		4 parts	
	9290	A1	5		
(ii)	Pcos30°x25	B1		or a=0.42	
	Pcos30°.25=9290 / Pcos30°-70-80x9.8sin20°=80a	M1			
	P = 429 /if P found 1st then Pcos30°x25 =9290 ok	A1	3		**8**

Q7, (Jun 2005, Q6)

(i)	$\frac{1}{2}.700.20^2$ or $\frac{1}{2}.700.15^2$	B1		either K.E.	
	700x9.8x400sin5°	B1		correct P.E.	
	$\frac{1}{2}.700.15^2+700.9.8.400\sin5°=$ $\frac{1}{2}.700.20^2$ + W.D.	M1		for 4 terms with W.D.	
	W.D. = 178,000 J	A1	4	or 178 kJ	
(ii)	D=200 + 700.9.8sin5°	M1			
	D = 798 N	A1		may be implied	
	P = Dx15 = 12,000 = 12kW	A1	3	AG **(11,968W)**	
(iii)	D' = 11,968÷20 = 598	M1			
	D'-700.9.8sin5°-200 = 700a	M1			
	a = 0.285 ms^{-2} (±)	A1	3	allow 0.283 (from 12kW)	**10**
	Alternative for false assumption			**of constant acceleration**	
(i)	D-700 x 9.8sin5° = 700a and $15^2 = 20^2$ + 2a. 400	M1		(D = 445, a = -0.21875)	
	W.D. = 400xD = 178,000	A1		2 marks (out of 4) maximum	

Q8, (Jun 2014, Q5)

(i)		Driving Force = 10000/20 (= 500)	B1	
		$cv(10000/20) - 1300 + 800g\sin\alpha = 0$	M1 A1	Attempt at N2L with 3 terms
		$\sin\alpha = 5/49$	A1 **[4]**	**AG** at least one more line of correct working (at least e.g. $-800+800g\sin\alpha=0$); allow verification (e.g. 500 – 1300 + 800 = 0)
(ii)		$800(22.1)g\sin\alpha$	B1	Work done against weight; Need a value for $\sin\alpha$ or α
		$800(22.1)g\sin\alpha + 1300(22.1) + \frac{1}{2}(800)(8^2)$	M1 A1	Total work done, 3 terms needed Need a value for $\sin\alpha$ or α; (72010 J)
		$t = 3.6(0)$ s	M1 A1 **[5]**	Time = work done(from at least one correct energy term)/power 'Exact' is 3.6005

Q9, (Jan 2009, Q4)

(i)	$P/10 - 800x9.8\sin12° - 100k = 800x0.25$	M1	$P/10 = D_1$ ok
		A1	D_1 ok
	$P/20 - 400k = 800x0.75$	M1	$P/20 = D_2$ ok
		A1	$D_1 = 2D_2$ needed for this A1
	solving above	M1	
	$k = 0.900$	A1	**AG** 0.9000395
	$P = 19\,200$	A1 **7**	or 19.2 kW (maybe in part (ii))
(ii)	$0.9v^2 = 28\,800/v$	M1	ok if $19200/v$
	solving above	M1 *	$(v^3 = 32\,000)$
	$v = 31.7$ m s^{-1}	A1 **3**	**10**

Q10, (Jan 2013, Q6)

(i)		Use I = mv 3.6 ms^{-1}	M1 A1 **[2]**	-3.6 gets A0	
(ii)		±(½ x 0.5 x 3.6^2 - ½ x 0.5 x v^2) 0.5 x g x 0.3 Use of conservation of energy v = 2.66 ms^{-1}	B1 B1 M1 A1 **[4]**	Three terms	
(iii)		Change in energy = ±(½ x 0.5 x 3^2 - 0.5 x g x 0.2) Equate to force x distance 3.175 N	M1 A1 M1 A1 **[4]**	Difference of KE and PE Attempt at 0.2/sin30 for dist, 3 terms Allow 3.18	
OR		Using $v^2 = u^2 + 2as$ to find a Resolve parallel to plane 0.5gcos60 + F = 0.5 x cv(11.25) F = 3.175	M1 M1 A1 A1	Use v = 0, attempt at s =0.2/sin30 N2L used with cv(11.25), 3 terms Consistent signs Allow 3.18	

Questions Involving Coefficient of Friction (Aimed at Year 2 Students)

Q1, (Jan 2008, Q2)

$F = 0.2\ mg\ \cos30°$	M1		=
	A1		= (1.6974m) (49√3/50m)
$0.2mg\cos30° \times d$	B1		$a=0.2g\cos30°+g\sin30°$
$mg \times d \times \sin30°$	B1		$a= (\pm)\ 6.60$
$d=½x25/(0.2x9.8\cos30°+9.8x\sin30°)$	M1		$0 = 5^2 – 2x6.60d$
1.89 m	A1	**6**	

Q2, (Jun 2010, Q7)

(i)	$R = 0.2 \times 9.8 \times \cos30°$ (= 1.70)	B1		
	$F = 0.1 \times 9.8 \times \cos30°$ (= 0.849) FT	B1		FT on their R, but not R =0.2g
		M1		Use of conservation of energy
	$½ \times 0.2 \times 11^2 - ½ \times 0.2\ v^2 =$	A1		
	$0.2 \times 9.8 \times 5\sin30 + 5 \times 0.849$	A1		
	$v = 5.44\ m\ s^{-1}$	A1	**6**	**AG**
Or last 4 marks of (i)	$F + 0.2g\sin30 = \pm0.2a$	M1		Use of N2L, 3 terms
	$a = \pm9.1$	A1		
	$v^2 = 11^2 + 2 \times a \times 5$	M1		Complete method to find v
	$v = 5.44\ m\ s^{-1}$	A1		
(ii)	$t = 5\cos30°/5.44\cos30°$	M1		time to lateral position over *C*
	$t = 0.919$ s	A1		
	$u = 5.44\sin30°$ (= 2.72)	B1		
	$s = 2.72 \times 0.919 – 4.9 \times 0.919^2$	M1		
	$s = -1.6$ (or better)	A1		Ht dropped
	Ht drop to *C* = $5\sin30° = 2.5$ m	B1		
	Ball does not hit the roof	A1	**7**	**13**
Or first 5 marks of (ii)	$y = x\tan\theta – gx^2\sec^2\theta/2V^2$	B1		
	substitute values	M1		
	$V = 5.44 \quad \theta = 30° \quad x = 5\cos30°$	A1		all 3 correct
	$y = 2.5 – 9.8x25x3/4x4/3\ /\ (2x5.44^2)$	A1		
	$y = -1.6$ (or better)	A1		
OR (ii)	$u = 5.44\sin30°$ (= 2.72)	B1		
	$-2.5 = 5.44\sin30t – 4.9t^2$	M1		
		A1		aef
	$t = 1.04$	A1		time to position level with *AC*
	$x = 5.44\cos30 \times 1.04 = 4.9$ (or better)	A1		
	Horizontal distance from B to C = $5\cos30 = 4.3$(or better)	B1		
	Ball does not hit the roof	A1	**7**	

OR (ii)	$y = x\tan\theta - gx^2\sec^2\theta/2V^2$	B1	
	substitute values	M1	
	$-2.5 = 0.577x - 0.221x^2$	A1	aef
	Attempt to solve quadratic for x	M1	
	x = 4.9 (or better)	A1	
	Horizontal distance from B to C = $5\cos30 = 4.3$ (or better)	B1	
	Ball does not hit the roof	A1 **7**	
OR (ii)	$u = 5.44\sin30° = 2.72$	B1	
	$-2.5 = 5.44\sin30t - 4.9t^2$	M1	
		A1	aef
	t = 1.0 (or better)	A1	time to position level with *AC*
	$T = 5\cos30°/5.44\cos30°$	M1	
	T = 0.92 (or better)	A1	time to lateral position over *C*
	Ball does not hit the roof	A1 **7**	
OR (ii)	Attempt at equation of trajectory	M1	
	$y = 0.577x - 0.221x^2$	A1	
	y = -0.577x	B1	Equation of BC
	Solving their quadratic and linear equations to get at least x or y	M1	
	x = 5.2 (or better) or y = -3.0 (or better)	A1	
	Horizontal distance from B to C = $5\cos30 = 4.3$ (or better)		Must be the one needed for comparison
	Or Ht drop to *C* = $5\sin30° = 2.5$	B1	
	Ball does not hit the roof	A1 **7**	
OR (ii)	Attempt at equation of trajectory	M1	
	$y = 0.577x - 0.221x^2$	A1	
	y = -0.577x	B1	
	Solving their quadratic and linear equations	M1	
	x = 5.2 (or better) and y = -3.0 (or better)	A1	
	Distance = 6.0 (or better)	B1	Distance from B to point of intersection
	Ball does not hit the roof	A1 **7**	