Forces and Motion (Statics and Dynamics in 2d with Friction) (From OCR 4728)

Q1, (Jan 2006, Q4)

(i)	$F = 12\cos 15^\circ$	M1		Resolve horizontally (condone sin)
	Frictional component is 11.6 N	A1	[2]	Accept $12\cos 15^\circ$
(ii)	$N + 12\sin 15^\circ = 2g$	M1		Resolve vert 3 forces (accept cos)
	Normal component is 16.5 N	A1	[2]	AG
(iii)	$11.591\ldots = \mu\ 16.494\ldots$	M1		For using cv $F = \mu$ cv N
	Coefficient is 0.7(0)	A1ft	[2]	Ft cv F to 2 sf. $\mu = 0.7027....$
(iv)	$N = 2g$	B1		
	$F = 19.6 \times 0.7027\ldots$	M1		
		M1		For using Newton's second law
	$20 - 13.773\ldots = 2a$	A1ft		cv Tractive - cv Friction (e.g. from (i))
	Acceleration is 3.11 ms^{-2}	A1	[5]	Accept either 3.11 or 3.12 only
	MISREAD (omits "horizontal")	MR-1		All A and B marks now ft. Subtract "MR-1" from initial B1 or final A1 (not A1ft in main scheme).
	$N = 2g$ - 20sin15	B1ft		
	$F = 0.7027$ x 14.4	M1		Equals 14.42...
		M1		Equals 10.1....
	$20\cos 15 - 10.14 = 2a$	A1ft		For using Newton's second law
	Acceleration is 4.59 ms^{-2}	A1ft	[4]	cv Tractive - cv Friction Accept 4.59, 4.6(0)

Q2, (Jun 2006, Q7)

(i)	$0 = 6 + (\pm)1.5a$	M1		For using $v = u + at$ with $v = 0$
	$a = (\mp)4 ms^{-2}$	A1		
	$-mg\sin15^\circ - F = ma$	M1		For applying Newton's second law with 2 forces
	$-0.1 \times 9.8\sin15^\circ - F = 0.1 \times (-4)$	A1		
	$R = 0.1g\cos15^\circ$	B1		
	$0.146357 \ldots = \mu\, 0.946607$	M1		For using $F = \mu R$
	…			
	Coefficient is 0.155	A1	7	Anything between 0.15 and 0.16 inclusive
(ii)	$mg\sin15^\circ > \mu\, mg\cos15^\circ$ (or $\tan 15^\circ > \mu$)	M1		For comparing weight component with frictional force (or tan 'angle of friction' with μ)
	➔ particle moves down	A1	2	Awarded if conclusion is correct even though values are wrong
(iii)	$(6 + 0) \div 2 = s \div 1.5$	M1		For using $(u + v) \div 2 = s \div t$
	$s = 4.5$	A1		
	$mg\sin15^\circ - F = ma$	M1		For using Newton's second law with 2 forces
	$0.25364 \ldots - 0.146357 \ldots = 0.1a$	A1		Values must be correct even if not explicitly stated. Note that the correct value of friction may legitimately arise from a wrong value of μ and a wrong value of R
	$v^2 = 2(1.07285 \ldots)4.5$	M1		For using $v^2 = 2as$ with any value of a
	Speed is 3.11 ms^{-1}	A1	6	Accept anything rounding to 3.1 from correct working

Q3, (Jan 2009, Q4)

(i)	20cos 30	M1	Resolves 20 (accept 20 sin30)
	$20\cos30 = 3a$	M1	Uses N2L horizontally, accept g in ma term
	$a = 5.77\ ms^{-2}$	A1	
		[3]	
(ii)		M1	Resolves vertically (accept -, cos if sin in i); correct no. terms
	$R = 3x9.8 + 20 \sin 30\ (= 39.4)$	A1	
	$F = 20\cos 30\ (= 17.3)$	B1	Correct (Neither R nor F need be evaluated)
	$17.3 = 39.4\mu$	M1	Uses $F = \mu R$
	$\mu = 0.44$	A1	
		[5]	

Q4, (Jan 2008, Q6)

i	$4.9 = \mu \times 14.7$		M1	Uses $F = \mu R$
	$\mu = 1/3$	AG	A1	Allow 0.333 or 0.3 recurring
			[2]	
iia			M1	3 force vertical equation
	$R + 4.9\sin30 = 14.7$		A1	
	$R = 12.25$ N		A1	Accept 12.2 or 12.3
	$F = 12.25 \times 1/3$		M1	Uses $F = \mu R$ with new R {may be seen in
	$F = 4.08(333..)$ N [or 49/12 N]		A1	{part b
			[5]	
iib	$m = 14.7/9.8 = 1.5$kg		B1	
			M1	N2L horizontally with 2 relevant forces, including 4.9sin/cos30
	$4.9\cos30 - 4.08(333..) = 1.5a$		A1	Allow cv(F) ***SR*** Award A1 if m=14.7 used
	$a = 0.107$ ms^{-2}		A2	***SR*** A1 for 0.11, 0.109
iii			[5]	or art 0.011 from m = 14.7
	$\mu R = (14.7 - 4.9\cos30)/3$		B1	3.49, accept 3.5
	Horizontal component of force = $4.9\sin30$		B1	2.45, accept 2.4 or 2.5
	Horizontal component of force < ③R		M1	Comparing two values
	Friction = 2.45 N		A1	Not 2.4 or 2.5; Explicit (M1 essential)
			[4]	

Q5, (Jan 2010, Q4)

ia	0.3gcos 60 and 0.3gsin60	B1	Accept use of "m = 0.1 kg" for M1 and
	0.4gcos60 and 0.4gsin60	B1	0.1gcos60 (B1) 0.1gsin60 (B1)
	Calculates either relevant difference	M1	
	Perp = 0.1gcos60 and Para = +/- 0.1gsin60	A1	= 0.49 and = 0.849 (accept 0.85 and 0.84)
		[4]	
ib	$0.1g\sin60 = \mu 0.1g\cos60$	M1	$F = \mu R$, $F>R>0$
	$= 1.73$ ($= \sqrt{3}$)	A1	From correct R, F values
		[2]	
ii		M1	N2L for either particle no resolving, at least 1 unknown Formula round the pulley, M0A0. But award M1 for $T-0.4g = 0.4 \times 1.09$ etc later
	$0.5g - T = 0.5a$		
	$T - 0.4g = 0.4a$	A1	Both equations correct
	$a = 1.09$ ms^{-2}	B1	
	$T = 4.36$ N	B1	
		[4]	

Q6, (Jan 2010, Q7)

i	(Fr =) $0.15 \times 600g\cos 10$	B1	Implied by Fr = $0.15 \times 600g\cos 10$ (=868.6..)
	(Wt cmpt =) $600g\sin 10$	B1	
	$600 \times 0.11 = T - 0.15 \times 600g\cos 10 - 600g\sin 10$	M1	N2L. T with at least 1 resolved forces and 600×0.11
	$(66 = T - 868.6 - 1021)$	A1	
	$T = 1960$ N	A1 [5]	1955.6..
ii a	$a(up) = +/-(600g\sin 10 + .15 \times 600g\cos 10)/600$	M1	2 resolved forces and 600a or "unit mass"
	$a(up) = +/-3.15\ ms^{-2}$ AG	A1 [2]	Disregard sign, accept 3.149
b	UP $v^2 = 2 \times 0.11 \times 10$	M1	
	$v = 1.48$ when cable breaks	A1	Correct, need not be accurate
	$t = 1.48/3.149$	M1	Or $1.48 = 0 + 3.15t$
	$(t = 0.471$ time for log to come to rest)		
	$s = 1.48^2/(2 \times 3.149)$	M1	
	$s = 0.349$ distance for log to come to rest	A1	Correct, need not be accurate
	DOWN		
	$a(down) = (600g\sin 10 - 0.15 \times 600g\cos 10)/600$	B1	$= 0.254$
	$10 + 0.349 = 0.254t^2/2$	M1	Needs $a < 3.15$, $s > 10$. Or $V^2 = 2 \times 0.254 \times (10 + 0.349)$ [V= 2.29..], $V = 0.254t$
	$t = 9.025$	A1	Correct, need not be accurate
	$T = (9.025 + 0.471) = 9.5$ s	A1 [9]	Accept 9.49

Q7, (Jan 2012, Q6)

(i)		$R = 0.3g\cos30$ $Fr = 0.15 \times 0.3g\cos30$ $0.3a = -0.3g\sin30 - 0.15 \times 0.3g\cos30$ $a = -6.17$ $0 = 4^2 - 2 \times 6.17s$ $s = 1.3(0)$ m	B1 M1 M1 A1 M1 A1ft **[6]**	$R = 2.546$ N. May be shown on diagram $0.15 \times$ cv(R), $Fr = 0.382$ N2L, two forces inc. 0.3gCorS30 and friction Accept positive value Using a from above ft(8/ |cv(a)|) CorS30 means cos30 or sin30
(ii)		$0.3a = 0.3g\sin30 - 0.382$ $a = 3.63$ $1.3 = 3.63t^2/2$ $t = 0.845$ s	M1 A1 M1 A1 **[4]**	N2L, diff. of two forces inc. 0.3gCorS30 and friction Using cv(s**(i)**), and a not a**(i)** nor 9.8 Rounds to 0.85 if 2 sig fig. CorS30 means cos30 or sin30
(iii)		$V = 3.63 \times 0.845$ *OR* $V = \sqrt{(2 \times 3.63 \times 1.3)}$ *OR* $V = 2 \times 1.3/0.845$ ($V = 3.07$) Mom change = +/-($0.3 \times 4 + 0.3 \times 3.07$) Mom change = +/-2.12 kgms^{-1}	M1 M1 A1 **[3]**	cv(a**(ii)** $\times$ t**(ii)**) *OR* cv($\sqrt{2} \times a$**(ii)** $\times s$**(i)** *OR* cv($2 \times s$**(i)**/ t**(ii)**), a**(ii)** not a**(i)** nor 9.8 +/-(0.3×4 +/– $0.3 \times$ speed(return)), 0<speed(return) < 4, g omitted

Q8, (Jun 2014, Q6)

(i)		$3 = 8\mu$ $\mu = 0.375$	M1 A1 [2]	Uses $F = \mu R$, Allow R is 8 or $8g$, Fr =3 only 3/8 (fraction), not 3÷8 (division)	
(ii)		$C^2 = 3^2 + 8^2$ $C = 8.54$ N $\tan\theta$ =3/8 or $\tan\theta$ =8/3 $\theta = 20.6°$ with vertical or 69.4° with horizontal	M1 A1 M1 A1 [4]	Uses Pythagoras with 3 and 8 or $8g$ Accept 8.5 or $\sqrt{73}$ Uses tan with 3 and 8 or $8g$ Accept 21 or 69, direction clear by words or diagram.	Or CorS with answer for C isw work after correct angle magnitude found
(iii)	(a)	$T(\cos 0) - 3 = +/-3$ $T = 6$	M1 A1 [2]	$T(\cos 0) - 3 = 0$ is M0 Answer alone is sufficient for M1A1	$T\cos 0 - 3 = -3$ assumes Fr direction has not changed
(iii)	(b)	$R = +/-(8 - T \times \text{SorC}30)$ $R = 8 - T\sin 30$ $Fr = +/-(T \times \text{CorS}30 - 3)$ $Fr = T\cos 30 - 3$ $0.375 = (T\cos 30 - 3) / (8 - T\sin 30)$ $T = 5.70$ *OR* Alternative for last 4 marks $Fr = 0.375(8 - T\sin 30)$ $Fr = +/-(T \times \text{CorS}30 - 3)$ $Fr = T\cos 30 - 3$ $0.375(8 - T\sin 30) = T\cos 30 - 3$ $T = 5.70$	M1 A1 M1 A1 M1 A1 [6] - M1 A1 M1 A1	Accept $8g$ with cmpt T oe Accept 3 with cmpt T, not $T\times$CorS30+/–3= 0 oe Accept use of μ from (i). For forming an equation in T alone. Accept use of μ from (i). oe For forming an equation in T alone.	(This is required also in the SC case) SC Does not allow for change in direction of Friction $Fr = 3 - T\cos 30$ A1 $0.375 = (3 - T\cos 30) / (8 - T\sin 30)$ M1 $T = 0$ A0 SC (Alternative) $Fr = 0.375(8 - T\sin 30)$ $Fr = +/-(T \times \text{CorS}30 - 3)$ M1 $Fr = 3 - T\cos 30$ A1 $0.375(8 - T\sin 30) = (3 - T\cos 30)$ M1 $T = 0$ A0

Q9, (Jun 2012, Q6)

(i)		$mg = 6.4\cos 40$	M1	One cmpt of 6.4 N force (allow 6.4 x sin/cos 40 or 50), mg not resolved
		$m = 0.5(00)$	A1	Accept 0.5, g=9.81 (0.49976..=0.5) g=10 (0.49026.. = 0.49)
			[2]	
(ii)		$H = 6.4 + 6.4\sin 40$ OR $2 \times 6.4\cos 25 = 0.5g\cos 65 + H\cos 25$	M1	Resolves horizontally, all necessary terms (allow e.g. $6.4 \pm 6.4\cos 40$) Resolves parallel to bisector of strings, inc cmpt weight
		$H = 10.5$	A1	Accept 11
			[2]	
(iii)		$R = 32\cos 30 - 6.4\sin 30$	M1	Difference of Wt cmpt and Tension (not H) cmpt
		$R = 24.5$	A1	May be implied
		$Fr = 32\sin 30 + 6.4\cos 30$	M1	Sum of Wt cmpt and Tension (not H) cmpt
		$Fr = 21.5$	A1	May be implied
		$\mu = (32\sin 30 + 6.4\cos 30)/(32\cos 30 - 6.4\sin 30)$	M1	**Either** Fr **or** R obtained from 2 term numerical expressions, in $\lvert Fr\rvert = \mu\lvert R\rvert$
		$\mu = 0.879$ AG	A1	
			[6]	
(iv)		$F_{max} = 0.879 \times 32\cos 30$ (= 24.4 N)	B1*	May be described simply as F or friction
		Wt cmpt down slope = $32\sin 30$ (= 16 N)	D*M1	Finding Wt component down slope and comparing with friction
		Remains in eqbm	A1	Needs Wt cmpt = $16 < F_{max}$
		OR	**[3]**	
		$\pm ma = 32\sin 30 - 0.879 \times 32\cos 30$	B1*	For friction calculation
		Finds acceleration	D*M1	Sets up and solves N2L for a
		Remains in eqbm	A1	Needs a clearly in direction of friction (impossible)
		OR		
		angle of friction = $\tan^{-1}0.879 = 41°$	B1*	
		Slope is 30°	D*M1	Must be explicit
		Remains in eqbm	A1	Values of angle of friction and slope stated in 6(iv)

Q10, (Jun 2016, Q6)

i		T(before) = 0.2g = 1.96	**B1**	Evaluation not needed
		Fr = 0.4x0.2$g$cos30 (=0.67896..)	**B1**	Evaluation not needed, but accept 0.68
		0.2a = 0.2g – T Either correct	**M1**	$a \neq g$
		0.2a = T - 0.2$g$sin30 - 0.4x0.2$g$cos30 Both correct	**A1**	0.2g - T=T - 0.2$g$sin30 - 0.4x0.2$g$cos30 is M1A1 0.4a=0.2g - 0.2$g$sin30 - 0.4x0.2$g$cos30 is M1A1
		2T = 0.2g + 0.2$g$sin30 + 0.4x0.2$g$cos30	**M1**	Finding expression (2)T from two simultaneous
		T = 1.81 N	**A1**	equations in a and T. a = 0.7526.. m s^{-2}, but is not
			[6]	required
ii		THIS CANNOT BE SOLVED USING a(i)	**M1***	N2L with Fr and Weight component of P
		0.2a = +/- (0.2$g$sin30 + 0.4x0.2$g$cos30)	**A1**	Omitting g, M1*A0A0, D*M1A0 possible
		a = +/-(8.2948..)	**A1**	
		v^2 = 2x8.29(48..)x0.8 *OR* 0 = u^2 - 2x8.29(48..)x0.8	**D*M1**	Equations must lead to positive values for u^2, v^2
		v = 3.64 m s^{-1} or u = 3.64 m s^{-1}	**A1**	
			[5]	
iii			**M1**	Applies Pythagoras to Friction and Normal Reaction
		R^2 = (0.2$g$cos30)^2 + (0.4x0.2$g$cos30)^2	**A1**	Omitting g, M1A0A0 possible
		R=1.83 N	**A1**	
			[3]	