1	(a)	$(FH =)\ \sqrt{12^2+12^2}\ (=16.97...$ or $\sqrt{288}$ or $12\sqrt{2})$		3	M1
		$\tan CFH = \dfrac{10}{\text{"16.97..."}}$ oe **or** e.g. $(CF =)\ \sqrt{\text{"16.97"}^2+10^2}\ (=19.69...$ or $\sqrt{388}$ or $2\sqrt{97})$ **and** e.g. $\dfrac{\sin CFH}{10} = \dfrac{\sin 90}{\text{"19.69"}}$			M1 for a correct trig statement involving CFH
			30.5		A1 accept 30.4 – 30.7
	(b)	$(BG =)\ 10 + \sqrt{15^2-12^2}\ \ (=19)$		3	M1
		$(BE =)\ \sqrt{\text{"19"}^2+\text{"16.97..."}^2}$ oe			M1 ft their FH
			25.5		A1 accept 25.4 – 25.6
					Total 6 marks

2	$(AH =)\sqrt{6^2+5^2+9^2}\ \ (=\sqrt{142}\ )$ **or** $(FH = GE =)\ \sqrt{5^2+9^2}\ \ (=\sqrt{106}\ )$		4	M1 for working out AH or FH or GE
	E.g. $\sin AHF = \dfrac{6}{\text{'}\sqrt{142}\text{'}}$ **or** $\tan AHF = \dfrac{6}{\text{'}\sqrt{106}\text{'}}$ **or** $\cos AHF = \dfrac{\text{'}\sqrt{106}\text{'}}{\text{'}\sqrt{142}\text{'}}$ **or** $\sin FAH = \dfrac{\text{'}\sqrt{106}\text{'}}{\text{'}\sqrt{142}\text{'}}$ **or** $\cos FAH = \dfrac{6}{\text{'}\sqrt{142}\text{'}}$ **or** $\tan FAH = \dfrac{\text{'}\sqrt{106}\text{'}}{6}$			M1 for a correct method for finding angle AHF **or** finding angle FAH Allow $\cos AHF = \left(\dfrac{\text{'}\sqrt{142}\text{'}^2+\text{'}\sqrt{106}\text{'}^2-6^2}{2\times\text{'}\sqrt{142}\text{'}\times\text{'}\sqrt{106}\text{'}}\right)$ oe **or** $\sin AHF = \dfrac{\sin 90}{\text{'}\sqrt{142}\text{'}}\times 6$ oe
	E.g. $\sin^{-1}\left(\dfrac{6}{\text{'}\sqrt{142}\text{'}}\right)$ **or** $\tan^{-1}\left(\dfrac{6}{\text{'}\sqrt{106}\text{'}}\right)$ **or** $\cos^{-1}\left(\dfrac{\text{'}\sqrt{106}\text{'}}{\text{'}\sqrt{142}\text{'}}\right)$ **or** $90-\sin^{-1}\left(\dfrac{\text{'}\sqrt{106}\text{'}}{\text{'}\sqrt{142}\text{'}}\right)$ **or** $90-\cos^{-1}\left(\dfrac{6}{\text{'}\sqrt{142}\text{'}}\right)$ **or** $90-\tan^{-1}\left(\dfrac{\text{'}\sqrt{106}\text{'}}{6}\right)$			M1 for a complete method Allow $\cos^{-1}\left(\dfrac{\text{'}\sqrt{142}\text{'}^2+\text{'}\sqrt{106}\text{'}^2-6^2}{2\times\text{'}\sqrt{142}\text{'}\times\text{'}\sqrt{106}\text{'}}\right)$ oe **or** $\sin^{-1}\left(\dfrac{\sin 90}{\text{'}\sqrt{142}\text{'}}\times 6\right)$ oe
		30.2		A1 for 30.2 – 30.3
				Total 4 marks

3	$[AM =]\sqrt{5^2+15^2}\ (=\sqrt{250}=15.8...)$ where M is midpoint of EF, oe other correct method to find AM $[AD =]\sqrt{12^2+15^2}\ (=\sqrt{369}=19.2...)$ $[DM =]\sqrt{12^2-5^2}\ (=\sqrt{119}=10.9...)$		4	M2 (M1	for a complete method to find **two** of AM, AD, DM (where M is the midpoint of EF) Other longer ways to find AM, AD, DM may be used but must be a complete method eg $\angle DEM = \cos^{-1}(\frac{5}{12})(=65.37...)$ **and** $DM = 12\sin 65.37...$ $\angle DEM = \cos^{-1}(\frac{5}{12})(=65.37...)$ **and** $DM = 5\tan 65.37...$ Use $10 \div 2$ as 5 throughout For a complete method to find **one** of AM, AD, DM (where M is the midpoint of EF))
	eg $\tan DAM = \dfrac{\text{"}\sqrt{119}\text{"}}{\text{"}\sqrt{250}\text{"}}\left(=\dfrac{\text{"10.9..."}}{\text{"15.8..."}}\right)$ oe **or** $\sin DAM = \dfrac{\text{"}\sqrt{119}\text{"}}{\text{"}\sqrt{369}\text{"}}\left(=\dfrac{\text{"10.9..."}}{\text{"19.2..."}}\right)$ oe **or** $\cos DAM = \dfrac{\text{"}\sqrt{250}\text{"}}{\text{"}\sqrt{369}\text{"}}\left(=\dfrac{\text{"15.8..."}}{\text{"19.2..."}}\right)$ oe			M1	a correct method to find the required angle –other longer methods may be used but they must get to the stage of an equation for the required angle eg $\sin DAM = \dfrac{\text{"10.9..."}}{\sqrt{\text{"15.8..."}^2+\text{"10.9..."}^2}}$ NB: "10.9…" and "15.8…" must come from correct working
	Working not required, so correct answer scores full marks (unless from obvious incorrect working)	34.6		A1	any answer which rounds to 34.6
					Total 4 marks

4	$\sin\left(\frac{180-140}{2}\right)=\frac{MB}{8}$ oe or $\cos\left(\frac{140}{2}\right)=\frac{MB}{8}$ oe **or** $\frac{8}{\sin 20}=\frac{AC}{\sin 140}$ **and** $(MB^2)=8^2-\left(\frac{"15.035"}{2}\right)^2$ **or** $AC=\sqrt{8^2+8^2-2\times8\times8\times\cos 140}$ (=15.035…) **and** $(MB^2)=8^2-\left(\frac{"15.035"}{2}\right)^2$		4	M1	for a correct expression with MB included, or an expression for MB^2 If using sine or cosine rule on the isosceles triangle ABC, use of Pythagoras required to obtain an expression for MB^2
	$(MB=)$ 8sin("20") (= 2.736) or $(MB=)$ 8cos("70") (= 2.736) or $(MB)=\sqrt{8^2-\left(\frac{"15.035"}{2}\right)^2}$			M1	
	$\tan TMB=\frac{10}{"2.736"}$			M1	dep 1st M1
		74.7		A1	74.65 to 74.75
					Total 4 marks

5	(b)	eg $\sqrt{24^2+(37-"4.5")^2}(=40.4)$ $(AF=)$ $\sqrt{24^2+20^2+(37-"4.5")^2}$ (= 45.08...)		3	M1	Correct method to find diagonal from A to point on HE below F **or** AF
		$\tan x=\frac{20}{"40.4"}$ or $\sin x=\frac{20(\sin 90)}{"45.08"}$ or $\cos x=\frac{"40.4"^2+"45.08"^2-20^2}{2\times"40.4"\times"45.08"}$			M1	Correct trig statement for finding the required angle
			26.3		A1	26.3 – 26.4

6	eg $(BV^2=)3^2+6^2(=45)$ **or** $(CT^2=)3^2+6^2(=45)$ **or** $(DH^2=)$ 6^2+6^2 (= 72) **or** $(MV^2=)3^2+3^2(=18)$		4	M1	a correct expression for eg BV^2 **or** CT^2 **or** DH^2 **or** MV^2 where M is the midpoint of DC **or** a correct expression for [length]^2 for any length in the cube using Pythagoras	M3 for $(VT=)\sqrt{6^2+3^2+3^2}$ $(=3\sqrt{6}$ or 7.34...) (M2 for $(VT^2=)$ $6^2+3^2+3^2(=54)$)
	eg $(BV=)\sqrt{3^2+6^2}\left(=\sqrt{45}\text{ or }3\sqrt{5}\text{ or }6.70...\right)$ **or** $(CT=)\sqrt{3^2+6^2}\left(=\sqrt{45}\text{ or }3\sqrt{5}\text{ or }6.70...\right)$ **or** $(DH=)\sqrt{6^2+6^2}\left(=\sqrt{72}\text{ or }6\sqrt{2}\text{ or }8.48...\right)$ **or** $(MV=)\sqrt{3^2+3^2}\left(=\sqrt{18}\text{ or }3\sqrt{2}\text{ or }4.24...\right)$			M1	for a complete method for eg BV **or** CT **or** DH **or** MV **or** any length in the cube using Pythagoras	
	$(VT=)$ $\sqrt{"45"+3^2}$ **or** $\sqrt{\left(\frac{"\sqrt{72}"}{2}\right)^2+6^2}$ **or** $\sqrt{"18"+6^2}$ **or** $3\sqrt{6}$ **or** 7.34...			M1	for a correct expression for VT (condone missing brackets around $3\sqrt{5}$ or $3\sqrt{2}$ or $\frac{\sqrt{72}}{2}$)	
		$\sqrt{54}$		A1	if $\sqrt{54}$ seen and answer then given as $3\sqrt{6}$ isw and award full marks	
					Total 4 marks	

7	$(AC=)\ \sqrt{8^2+18^2}\left(=\sqrt{388}=2\sqrt{97}=19.697...\right)$ **or** $(CE=)\ \sqrt{8^2+18^2+12^2}\left(=\sqrt{532}=2\sqrt{133}=23.065...\right)$ oe		3	M1
	eg $\tan ECA=\left(\frac{12}{'\sqrt{388}'}\right)$ **or** $\sin ECA=\left(\frac{12}{'\sqrt{532}'}\right)$ **or** $\cos ECA=\left(\frac{'\sqrt{388}'}{'\sqrt{532}'}\right)$ **or** $\sin ECA=\frac{\sin 90\times 12}{'\sqrt{532}'}$ **or** $\cos ECA=\left(\frac{('\sqrt{388}')^2+('\sqrt{532}')^2-12^2}{2\times'\sqrt{388}'\times'\sqrt{532}'}\right)$ oe			M1 for a correct trig statement with *ECA* as the only unknown. NB allow use '*x*' or other variable in place of *ECA*.
		31.4		A1 allow 31.3 – 31.5
				Total 3 marks

8	eg $(AM=)\sqrt{x^2+(4x)^2}\left(=\sqrt{17x^2}=x\sqrt{17}\right)$ oe **or** $(AM=)\sqrt{(0.5x)^2+(2x)^2}\left(=\sqrt{\frac{17}{4}x^2}=x\frac{\sqrt{17}}{2}\right)$ oe **or** $(AM=)\sqrt{20^2+5^2}\left(=\sqrt{425}=5\sqrt{17}\right)$ oe		5	M1	for a correct method to find *AM* as a numerical value or in algebraic form, must have brackets or recover
	Height of triangle eg $\sqrt{(2x)^2-x^2}\left(=\sqrt{3x^2}=x\sqrt{3}\right)$ oe **or** $\sqrt{x^2-(0.5x)^2}\left(=\sqrt{\frac{3}{4}x^2}=x\frac{\sqrt{3}}{2}\right)$ oe **or** $\sqrt{10^2-5^2}\left(=\sqrt{75}=5\sqrt{3}\right)$ oe			M1	for a correct method to find height of equilateral triangle *HJK* as a numerical value or in algebraic form
	eg $\tan MAJ=\frac{\sqrt{3}+2}{\sqrt{17}}$ **or** $\tan MAJ=\frac{\frac{\sqrt{3}}{2}+1}{\frac{\sqrt{17}}{2}}$ **or** $\tan MAJ=\frac{5\sqrt{3}+10}{5\sqrt{17}}$			M1	for correct values for the correct angle (no algebra) **or** for $\tan MAJ$ is given numerically in the range 0.9 – 0.91
	eg $\frac{(\sqrt{3}+2)}{\sqrt{17}}\times\frac{\sqrt{17}}{\sqrt{17}}\left(=\frac{\sqrt{51}+2\sqrt{17}}{17}\right)$			M1	
		$\frac{\sqrt{68}+\sqrt{51}}{17}$		A1	or $\frac{\sqrt{51}+\sqrt{68}}{17}$
					Total 5 marks

9	$(AD=)\frac{2.2}{\tan 18}$ $(=6.77...)$ or $(EA=)\frac{2.2}{\sin 18}(=7.11...)$		4	M1	a correct method to find *AD* or *AE*
	$(DB=)\sqrt{("6.77...")^2+6^2}$ $(=9.04...)$ or $(EB=)\sqrt{6^2+"7.11..."^2}$ $(=9.31...)$ or $(EB=)\sqrt{6^2+"6.77..."^2+2.2^2}(=9.31...)$			M1	a correct method to find *DB* or *EB*
	$\tan DBE=\frac{2.2}{"9.04..."}$ or $\sin DBE=\frac{2.2}{"9.31..."}$ or $\sin DBE=\frac{2.2\sin 90}{"9.31..."}$ $\cos DBE=\frac{"9.04..."}{"9.31..."}$ or use of cosine rule			M1	complete method to find one of tan*DBE* or sin*DBE* or cos*DBE*– NB: if using cosine, the student will need to have found *DB* and *EB* previously
	Correct answer scores full marks (unless from obvious incorrect working)	13.7		A1	Allow answers in range 13.59 – 13.8
					Total 4 marks

10	$[DN =] 8\sin 30$ **or** $8\cos 60\ (= 4)$ oe [where N is the midpoint of EC] **or** $[x =] 8\cos 30$ **or** $8\sin 60 (= 4\sqrt{3} = 6.928...)$ **or** $2x = \sqrt{8^2 + 8^2 - 2\times 8\times 8\times \cos 120}(= \sqrt{192} = 8\sqrt{3} = 13.85....)$		5	M1	
	$[DN =] 8\sin 30$ **or** $8\cos 60\ (= 4)$ oe eg $\sqrt{8^2 - (4\sqrt{3})^2}(= 4)$ **And 1 of** $[x =] 8\cos 30$ **or** $8\sin 60 (= 4\sqrt{3} = 6.928...)$ oe or $\sqrt{8^2 - "4"^2}(= 4\sqrt{3} = 6.928...)$ **or** $2x = \sqrt{8^2 + 8^2 - 2\times 8\times 8\times \cos 120}(= 8\sqrt{3} = 13.85....)$			M1	[$(JM =)\ 4 + 4\sqrt{3}$ implies M2]
	$[AM =]\sqrt{12^2 + ("4\sqrt{3}")^2}\ (= \sqrt{192} = 8\sqrt{3} = 13.856\ldots)$ oe [where M is the midpoint of GH]			M1	**Clear intention to be AM (not EC)**
	$\tan MAJ = \left(\frac{"4"+"4\sqrt{3}"}{"8\sqrt{3}"}\right)$ oe eg $\tan MAJ = \left(\frac{10.928...}{13.856...}\right)$ if student uses sin or cos, then $AJ = 17.647\ldots$ to award marks this must come from a correct method or be correct			M1	
	Correct answer scores full marks (unless from obvious incorrect working)	38.3		A1	Accept 38.1 – 38.4 If no marks scored then award SCB2 for $\tan MAJ = \frac{4+x}{\sqrt{x^2+12^2}}$ or SCB1 for $AM = \sqrt{x^2+12^2}$
					Total 5 marks

11	(b)	$(UR =) 42\tan 30\ (= 14\sqrt{3} = 24.2(487\ldots))$ or $(UR =)\frac{42\times \sin 30}{\sin(90-30)}\ (= 14\sqrt{3} = 24.2(487\ldots))$		3	M1
		$\tan(UMR) = \left(\frac{"24.248..."}{42\div 2}\right)$ or $\tan(UMR) = \left(\frac{"24.248..."}{21}\right)$ or $\tan(UMR) = \left(\frac{"14\sqrt{3}"}{21}\right)$ or $(UM =)\sqrt{\left(\frac{42}{2}\right)^2 + \left("14\sqrt{3}"\right)^2}\ \left(= 7\sqrt{21} = 32.0(780...)\right)$ **and** $\sin(UMR) = \left(\frac{"14\sqrt{3}"}{"7\sqrt{21}"}\right)$ or $\cos(UMR) = \left(\frac{21}{"7\sqrt{21}"}\right)$			M1
		Correct answer scores full marks (unless from obvious incorrect working)	49.1		A1 awrt 49.1

12	$9^2 = 11^2 + 16^2 - 2 \times 11 \times 16 \times \cos BCA$ oe or $11^2 = 9^2 + 16^2 - 2\times9\times16\times\cos BAC$ or $16^2 = 9^2 + 11^2 - 2\times9\times11\times\cos ABC$ or (area of $\triangle ABC =)\sqrt{18\times2\times7\times9}(=47.6235...)$ oe		5	M1	For a start to the correct method to find angle BCA or angle BAC or angle ABC or a fully correct method to find the area of the triangle
	$(\cos BCA =)\left(\frac{11^2+16^2-9^2}{2\times11\times16}\right)(BCA = 32.763...)$ or $(\cos BAC =)\left(\frac{9^2+16^2-11^2}{2\times9\times16}\right)(BAC = 41.409...)$ or $(\cos ABC =)\left(\frac{9^2+11^2-16^2}{2\times9\times11}\right)(ABC = 105.826...)$ or $\frac{1}{2}\times16\times BD = "47.6235..."$			M1	For a correct rearrangement for $\cos BCA$ or $\cos BAC$ or $\cos ABC$ or a correct equation to find BD (accept angles to the nearest whole number rounded or truncated as long as not from incorrect working)
	$(BD =)$ 11 sin"32.763..."(= 5.95...) oe eg 11 sin(180 – "41.4…" – 105.8…") (= 5.95…) or 9 sin"41.4…." (= 5.95…) oe or $\frac{"47.6235..."\times2}{16}(=5.95...)$ oe or $\sqrt{11^2-"9.25"^2}$ or $\sqrt{9^2-"6.75"^2}$ $11\sin\left(\sin^{-1}\left(\frac{9\sin"105.826..."}{16}\right)\right)$ (= 5.95…) oe			M1	For a correct calculation that will lead to the value of BD "47.6235…" may also come from 0.5 × 9 × 11 × sin"105.8…" or 0.5 × 9 × 16 × sin"41.4…" or 0.5 × 16 × 11 × sin"32.7…" [Students may find an angle by sine rule after already finding an angle and use this]
	$\tan FDB = \frac{10}{"5.95..."}$ oe			M1	For a correct expression for the required angle (in form $\tan x = \ldots$ or $\cos x = \ldots$ or $\sin x = \ldots$) oe
	Correct answer scores full marks (unless from obvious incorrect working)	59.2		A1	awrt 59.2
	SEE OVER FOR ALTERNATIVE SCHEME				**Total 5 marks**

Angle DBC = 57.237…Angle ABD = 48.591…AD = 6.75 m CD = 9.25 m

12	$BD^2 = 11^2 - (16-y)^2$ and $BD^2 = 9^2 - y^2$ oe		5	M1	For 2 different expressions in the same single variable for BD or BD^2
	$11^2 - (16-y)^2 = 9^2 - y^2$ (y = 6.75 or x = 9.25)			M1	Equating the 2 expressions
	$BD = \sqrt{9^2-(16-"9.25")^2}$ or $\sqrt{11^2-"9.25"^2}$ (= 5.95)			M1	A correct calculation to find BD ("9.25" or "6.75" must come from a correct method)
	$\tan FDB = \frac{10}{"5.95..."}$ oe			M1	For a correct expression for the required angle (in form $\tan x = \ldots$ or $\cos x = \ldots$ of $\sin x = \ldots$) oe
	Correct answer scores full marks (unless from obvious incorrect working)	59.2		A1	awrt 59.2
					Total 5 marks