Circular motion and gravity *[162 marks]*

1. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

2. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

3. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

4. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

5. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

6.

[1 mark]

Markscheme

A

Examiners report

[N/A]

7.

[1 mark]

Markscheme

B

Examiners report

Think units.

If we want a speed then this can only be calculated from the area under the graph.

8.

[1 mark]

Markscheme

A

Examiners report

[N/A]

9.

[1 mark]

Markscheme

B

Examiners report

[N/A]

10.

[1 mark]

Markscheme

D

Examiners report

Gradient is in ms^{-1} giving a speed, so A and B must be wrong. Most candidates went for C although it is the only one that does not have a non-zero initial velocity.

11. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

12. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

13. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

14. *[1 mark]*

Markscheme

A

Examiners report

On the surface of a planet the gravitational field strength can be taken as invariant. This did not confuse the candidates although there were a number of teachers who wondered how high the crater was and whether this would affect the acceleration.

15a. *[3 marks]*

Markscheme

(i) s=12.5/12.6 (m);
Allow g =10ms^{-2} , answer is 12.8.

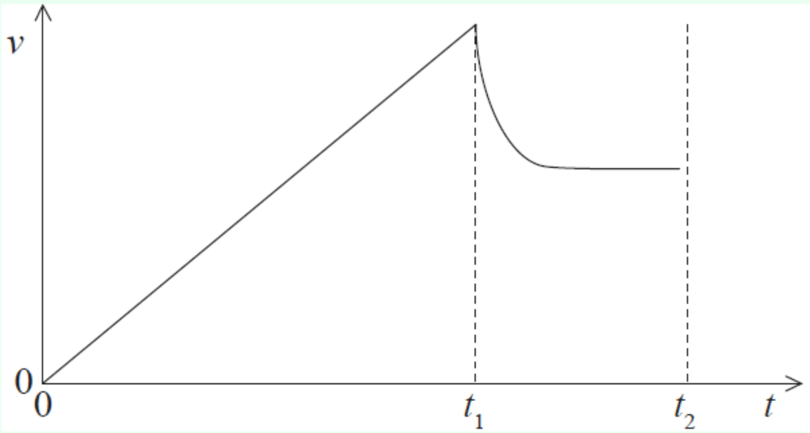
(ii) $v = \sqrt{2gs}$ ***or*** *gt; (allow any use of suvat equations)*
$= \left(\sqrt{2 \times 9.8 \times 12.5} =\right) 15.7 \left(\mathrm{ms}^{-1}\right)$;
*Award **[2]** for a bald correct answer.*
Allow g = 10ms^{-2} answer is 16.0 ms^{-1}.
Allow ECF from (a)(i)

Examiners report

(i) and (ii) These were high scoring questions with a substantial number of correct solutions. Even those who could not answer (i) were able to take their incorrect value and use it correctly in (ii).

15b. *[3 marks]*

Markscheme



straight line to water surface; *(allow a slight curve within 10 % of t_1)* clear decrease after hitting surface; (*allow straight line or concave curve as shown, do not allow convex curve*)

constant non-zero speed reached smaller than maximum; (*speed must be less than maximum velocity*)

Do not penalize answers where a curve is drawn to the dotted lines as there should not be a discontinuity at the two lines. Do not penalize if the line continues to t_2 or zero velocity shown at t_2.

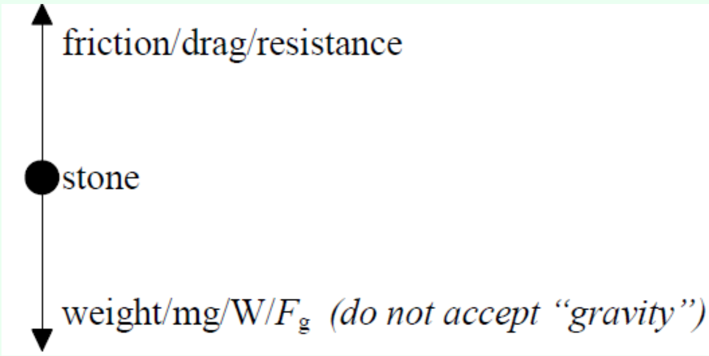
Examiners report

This part was not straightforward and demands some thought by candidates – ideally before they put pen to paper. A number of candidates achieved two marks. Common faults included: setting the final speed in the water at higher than the final speed in air; a significantly curved first section before t_1; incorrect curvature between t_1 and t_2 and lack of a final constant speed or a zero final speed.

15c.

[2 marks]

Markscheme



correctly labelled forces;

correct direction and equal lengths; *(judge by eye)*

Accept co-linear/vector arrows that do not begin at the stone.

Accept arrow heads finalizing at the stone.

Treat mention of upthrust as neutral.

Examiners report

This straightforward question was not well done. Many candidates did not draw two clear lines of appropriate length with a ruler – crude, free-hand sketches were very common. The question asks for labelling and this should be done with words, not symbols. Mention of up thrust was not required in the answer, although its inclusion was treated as neutral.

16.

[1 mark]

Markscheme

A

Examiners report

Response C was the most popular one at both levels. The magnitude of the gradient is the acceleration due to gravity, which of course is constant close to the Earth‟s surface.

17.

[1 mark]

Markscheme

D

Examiners report

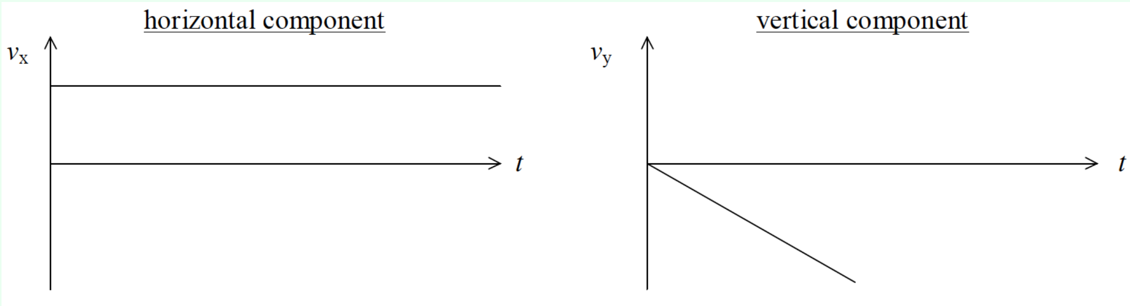
[N/A]

18a. *[3 marks]*

Markscheme

(i) zero;

(ii) horizontal: any horizontal line not on *t*-axis *(accept lines above or below t-axis)*;
vertical: any diagonal line starting at origin *(accept positive or negative gradients)*;



Examiners report

[N/A]

18b. *[4 marks]*

Markscheme

(i) $s_y = \frac{1}{2}a_yt^2 \Rightarrow 110 = \frac{1}{2} \times 10 \times t^2$;
t=4.690≈4.7s;

(ii) s_x=u_xt=5.0×4.690;
s_x=23m;

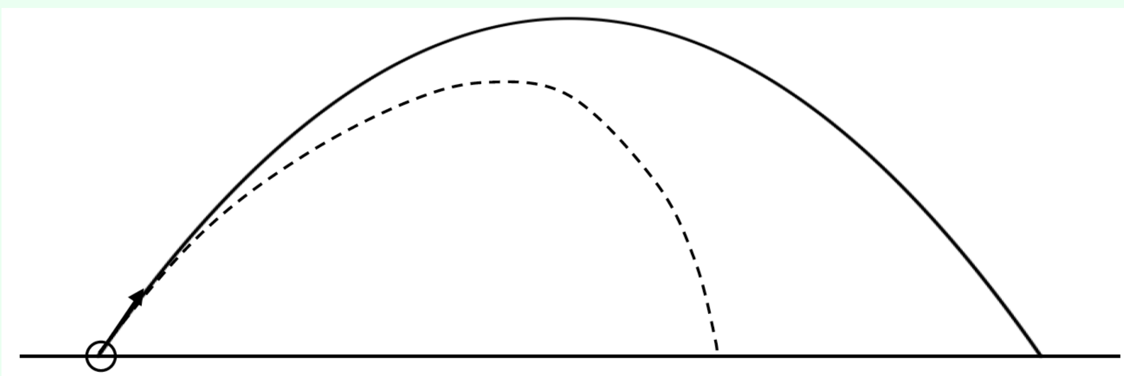
Examiners report

[N/A]

18c. *[3 marks]*

Markscheme

lower maximum height;
lower horizontal range;
asymmetrical with horizontal range before maximum height more than horizontal range after maximum height;



Examiners report

[N/A]

19a.

[2 marks]

Markscheme

$h = \frac{v^2}{2g}$;
$= \left(\frac{225}{20} =\right) 11\text{m}$;

*Award **[1 max]** for 91m or 91.25m (candidate adds cliff height incorrectly).*

Examiners report

The kinematic solutions seen were very pleasing with clear explanations and correct answers. However some candidates added an extra 80 m to the answer having failed to appreciate that the answer should have been "from the point where it [the stone] was thrown", i.e. the top of the cliff.

19b.

[3 marks]

Markscheme

time to reach maximum height=1.5s;
time to fall 91m=4.3s;
total time=5.8s;
Answer can be alternatively expressed as 3.0 (to return to hand) +2.8 (to fall 80m) .

or

use of $s=ut+½at^2$;
$80=-15t+5t^2$ or $-80=15t-5t^2$;
$t=5.8$s;

Examiners report

Two routes to the answer were seen: a straightforward approach in which both sections of the motion are considered and totalled, and a method using a single determination of a quadratic equation from $s = ut + 1/2at^2$. Only about half the candidates using the second route were able to arrive at the answer without error. The first approach was well done by the majority attempting this route.

20.

[1 mark]

Markscheme

B

Examiners report

[N/A]

21.

[1 mark]

Markscheme

D

Examiners report

Energy consideration (with the masses cancelling) leads to D as the correct response.

22a.

[1 mark]

Markscheme

$11\ \mathrm{ms}^{-2}$;

Examiners report

Most candidates were able to score well on this part.

22b.

[3 marks]

Markscheme

$\Delta v = 236$;

$a = \left(\frac{236}{8} =\right)\ 29.5\ \left(\mathrm{m\,s}^{-2}\right)$;

$(F = 1.1 \times 10^4 \times 29.5) = 3.2 \times 10^5\ \mathrm{N}$;

*Award **[2 max]** for omission of initial speed (answer is 390 kN).*

*Award **[3]** for correct bald answer.*

Examiners report

There were widespread failures to achieve the correct intermediate step of evaluating the acceleration in stage 2. The initial speed was often taken to be zero.

22c.

[2 marks]

Markscheme

phase 1 distance 88 m / phase 2 distance 1296 m;

total 1400 m;

*Award **[2]** for correct bald answer.*

Watch for significant figure penalty in this question (1384 m).

*Award **[1 max]** for $\frac{1}{2}at^2$ substituted correctly for first phase, if no distances*

evaluated and answer incorrect.

*Award **[1 max]** for correct addition of incorrect phase 1 and/or 2 distance(s).*

Examiners report

This very simple part caused problems for many who were unable to calculate the distances travelled in each stage, or add these together correctly.

23.

[1 mark]

Markscheme

B

Examiners report

[N/A]

24.

[1 mark]

Markscheme

A

Examiners report

[N/A]

25.

[1 mark]

Markscheme

B

Examiners report

[N/A]

26.

[1 mark]

Markscheme

C

Examiners report

As many teachers pointed out the question should have referred to the tension in the string rather than the centripetal force. This clearly also confused many of the candidates and the question was discounted.

27.

[1 mark]

Markscheme

C

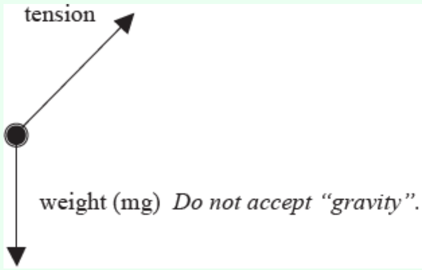
Examiners report

[N/A]

28a. *[4 marks]*

Markscheme

(i) ***[1]*** each for correct arrow and (any reasonable) labelling;



*Award **[1 max]** for arrows in correct direction but not starting at the ball.*

(ii) no;
because the two forces on the ball can never cancel out / there is a net force on the ball / the ball moves in a circle / the ball has acceleration/it is changing direction;
*Award **[0]** for correct answer with no or wrong argument.*

Examiners report

[N/A]

28b. *[3 marks]*

Markscheme

$T\left(=\frac{mg}{\cos 30^\circ}\right)=2.832\text{N}$;
$\frac{mv^2}{r}=T\sin 30^\circ$;
$v=\left(\sqrt{\frac{Tr\sin 30^\circ}{m}}=\sqrt{\frac{2.832\times 0.33\times \sin 30^\circ}{0.25}}\right)=1.4\text{ms}^{-1}$;

or

$T\cos 30^\circ=mg$;
$T\sin 30^\circ=\frac{mv^2}{r}$;
$v=\left(\sqrt{gr\tan 30^\circ}=\sqrt{9.81\times 0.33\times \tan 30^\circ}\right)=1.4\text{ms}^{-1}$;

Examiners report

[N/A]

29. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

30. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

31. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

32a. *[3 marks]*

Markscheme

$\frac{mv^2}{r} = G\frac{Mm}{r^2}$

leading to $T^2 = \frac{4\pi^2 r^3}{GM}$

T = 5320 «s»

Alternative 2

«$v = \sqrt{\frac{GM_E}{r}}$» = $\sqrt{\frac{6.67\times10^{-11}\times6.0\times10^{24}}{6600\times10^3}}$ ***or*** 7800 «ms^{-1}»

distance = $2\pi r$ = 2π x 6600 x 10^3 «m» or 4.15 x 10^7 «m»

«$T = \frac{d}{v} = \frac{4.15\times10^7}{7800}$» = 5300 «s»

Accept use of ω instead of v

Examiners report

[N/A]

32b. *[2 marks]*

Markscheme

T = «$\frac{2.90\times10^{-3}}{\lambda_{max}} =$» $\frac{2.90\times10^{-3}}{10.1\times10^{-6}}$

= 287 «K» ***or*** 14 «°C»

*Award **[0]** for any use of wavelength from Sun*

Do not accept 287 °C

Examiners report

[N/A]

32c. *[3 marks]*

Markscheme

wavelength of radiation from the Sun is shorter than that emitted from Earth «and is not absorbed by the atmosphere»

infrared radiation emitted from Earth is absorbed by greenhouse gases in the atmosphere

this radiation is re-emitted in all directions «including back to Earth»

Examiners report

[N/A]

32d. *[1 mark]*

Markscheme

peer review

international collaboration

full details of experiments published so that experiments can repeated

[Max 1 Mark]

Examiners report

[N/A]

33. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

34. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

35. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

36. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

37. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

38. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

39. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

40a. *[2 marks]*

Markscheme

$\frac{1}{2}v^2 = 0.24\text{gh}$

$v = 11.9$ «m s^{-1}»

Award GPE lost = 65 × 9.81 × 30 = «19130 J»

Must see the 11.9 value for MP2, not simply 12.

Allow g = 9.8 ms^{-2}.

Examiners report

[N/A]

40b. *[2 marks]*

Markscheme

internal energy is the total KE «and PE» of the molecules/particles/atoms in an object

temperature is a measure of the average KE of the molecules/particles/atoms

*Award **[1 max]** if there is no mention of molecules/particles/atoms.*

Examiners report

[N/A]

40c. *[2 marks]*

Markscheme

arrow vertically downwards from dot labelled weight/W/mg/gravitational force/F_g/$F_{gravitational}$ ***AND*** arrow vertically upwards from dot labelled reaction force/R/normal contact force/N/F_N

W > R

Do not allow gravity.
Do not award MP1 if additional ‘centripetal’ force arrow is added.
Arrows must connect to dot.
Ignore any horizontal arrow labelled friction.
Judge by eye for MP2. Arrows do not have to be correctly labelled or connect to dot for MP2.

Examiners report

[N/A]

40d. *[3 marks]*

Markscheme

ALTERNATIVE 1

recognition that centripetal force is required / $\frac{mv^2}{r}$ seen

= 468 «N»

W/640 N (weight) is larger than the centripetal force required, so the skier does not lose contact with the ground

ALTERNATIVE 2

recognition that centripetal acceleration is required / $\frac{v^2}{r}$ seen

a = 7.2 «ms^{-2}»

g is larger than the centripetal acceleration required, so the skier does not lose contact with the ground

ALTERNATIVE 3

recognition that to lose contact with the ground centripetal force ≥ weight

calculation that v ≥ 14 «ms^{-1}»

comment that 12 «ms^{-1}» is less than 14 «ms^{-1}» so the skier does not lose contact with the ground

ALTERNATIVE 4

recognition that centripetal force is required / $\frac{mv^2}{r}$ seen

calculation that reaction force = 172 «N»

reaction force > 0 so the skier does not lose contact with the ground

Do not award a mark for the bald statement that the skier does not lose contact with the ground.

Examiners report

[N/A]

40e. *[3 marks]*

Markscheme

ALTERNATIVE 1

$0 = 8.2^2 + 2 \times a \times 24$ therefore a = «–»1.40 «m s^{-2}»

friction force = ma = 65 × 1.4 = 91 «N»

coefficient of friction = $\frac{91}{65 \times 9.81}$ = 0.14

ALTERNATIVE 2

$KE = \frac{1}{2}mv^2$ = 0.5 x 65 x 8.2^2 = 2185 «J»

friction force = KE/distance = 2185/24 = 91 «N»

coefficient of friction = $\frac{91}{65 \times 9.81}$ = 0.14

Allow ECF from MP1.

Examiners report

[N/A]

40f.

[2 marks]

Markscheme

«76 × 9.6»= 730
Ns ***OR*** kg ms^{-1}

Examiners report

[N/A]

40g.

[2 marks]

Markscheme

safety net extends stopping time

F = $\frac{\Delta p}{\Delta t}$ therefore *F* is smaller «with safety net»

OR

force is proportional to rate of change of momentum therefore *F* is smaller «with safety net»

Accept reverse argument.

Examiners report

[N/A]

41a.

[2 marks]

Markscheme

correct use of kinematic equation/equations

148.5 ***or*** 149 ***or*** 150 «m»

Substitution(s) must be correct.

Examiners report

[N/A]

41b.

[3 marks]

Markscheme

a = $\frac{27}{11}$ ***or*** 2.45 «m s^{-2}»

F – 160 = 492 × 2.45

1370 «N»

Could be seen in part (a).
*Award **[0]** for solution that uses a = 9.81 m s^{-2}*

Examiners report

[N/A]

41c.

[3 marks]

Markscheme

ALTERNATIVE 1

«work done to launch glider» = 1370 x 149 «= 204 kJ»

«work done by motor» $= \frac{204 \times 100}{23}$

«power input to motor» $= \frac{204 \times 100}{23} \times \frac{1}{11} = 80$ ***or*** 80.4 ***or*** 81 k«W»

ALTERNATIVE 2

use of average speed 13.5 m s^{-1}

«useful power output» = force x average speed «= 1370 x 13.5»

power input = «$1370 \times 13.5 \times \frac{100}{23}$ =» 80 ***or*** 80.4 ***or*** 81 k«W»

ALTERNATIVE 3

work required from motor = KE + work done against friction «$= 0.5 \times 492 \times 27^2 + (160 \times 148.5)$» = 204 «kJ»

«energy input» $= \frac{\text{work required from motor} \times 100}{23}$

power input $= \frac{883000}{11} = 80.3$ k«W»

*Award **[2 max]** for an answer of 160 k«W».*

Examiners report

[N/A]

41d.

[2 marks]

Markscheme

$\omega =$ «$\frac{v}{r} =$» $\frac{27}{0.6} = 45$

rad s^{-1}

Do not accept Hz.
*Award **[1 max]** if unit is missing.*

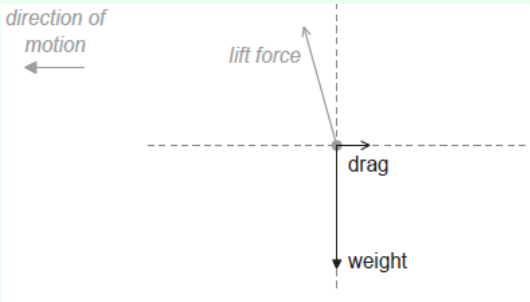
Examiners report

[N/A]

41e.

[2 marks]

Markscheme



drag correctly labelled and in correct direction

weight correctly labelled and in correct direction ***AND*** no other incorrect force shown

*Award **[1 max]** if forces do not touch the dot, but are otherwise OK.*

Examiners report

[N/A]

41f.

[2 marks]

Markscheme

name Newton's first law

vertical/all forces are in equilibrium/balanced/add to zero
OR
vertical component of lift mentioned

as equal to weight

Examiners report

[N/A]

41g.

[3 marks]

Markscheme

any speed and any direction quoted together as the answer

quotes their answer(s) to 3 significant figures

speed = 12.7 m s^{-1} ***or*** direction = 9.46° ***or*** 0.165 rad «below the horizontal» ***or*** gradient of $-\frac{1}{6}$

Examiners report

[N/A]

42.

[1 mark]

Markscheme

A

Examiners report

[N/A]

43.

[1 mark]

Markscheme

C

Examiners report

[N/A]

44a.

[2 marks]

Markscheme

(i) «gravitational» force per unit mass on a «small **or** test» mass

(ii) N kg^{-1}

Award mark if N kg^{-1} is seen, treating any further work as neutral.
Do not accept bald m s^{-2}

Examiners report

[N/A]

44b.

[4 marks]

Markscheme

i

clear evidence that *v* in $v^2 = \frac{4\pi^2R^2}{T^2}$ is equated to orbital speed $\sqrt{\frac{GM}{R}}$

OR

clear evidence that centripetal force is equated to gravitational force

OR

clear evidence that *a* in $a = \frac{v^2}{R}$ etc is equated to *g* in $g = \frac{GM}{R^2}$ with consistent use of symbols

Minimum is a statement that

$\sqrt{\frac{GM}{R}}$ *is the orbital speed which is then used in*

$v = \frac{2\pi R}{T}$

Minimum is $F_c = F_g$ *ignore any signs.*

Minimum is g = a.

substitutes and re-arranges to obtain result

Allow any legitimate method not identified here.

Do not allow spurious methods involving equations of shm etc

$$\ll T = \sqrt{\frac{4\pi^2 R}{\left(\frac{GM}{R^2}\right)}} = \sqrt{\frac{4\pi^2 R^3}{GM}} \gg$$

ii

«*T* = 365 × 24 × 60 × 60 = 3.15 × 10^7 s»

$$M = \ll \frac{4\pi^2 R^3}{GT^2} = \gg = \frac{4 \times 3.14^2 \times \left(1.5 \times 10^{11}\right)^3}{6.67 \times 10^{-11} \times \left(3.15 \times 10^7\right)^2}$$

2×10^{30}«kg»

Allow use of 3.16 x 10^7 s for year length (quoted elsewhere in paper).

Condone error in power of ten in MP1.

*Award **[1 max]** if incorrect time used (24 h is sometimes seen, leading to 2.66 x 10^{35} kg).*

Units are not required, but if not given assume kg and mark POT accordingly if power wrong.

*Award **[2]** for a bald correct answer.*

No sf penalty here.

Examiners report

[N/A]

45.

[1 mark]

Markscheme

D

Examiners report

[N/A]

46.

[1 mark]

Markscheme

A

Examiners report

[N/A]

47a. *[1 mark]*

Markscheme

$g=\frac{GM}{r^2}=\frac{6.67\times10^{-11}\times2.0\times10^{30}}{(6.0\times10^{11})^2}$

OR

3.71×10^{-4} Nkg^{-1}

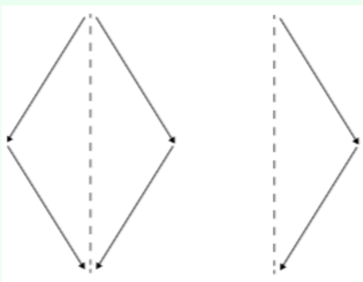
Examiners report

[N/A]

47b. *[2 marks]*

Markscheme

«g_{net} = 2cos34» 2*g* ***OR*** *g*cos34 ***OR*** *g*sin56 ***OR*** vector addition diagram shown



«g_{net} =«2×3.7×10^{-4} ×cos34^{o} =» 6.1×10^{-4} Nkg^{-1}

Examiners report

[N/A]

48a. *[2 marks]*

Markscheme

two arrows each along the line connecting the planet to its star ***AND*** directed towards each star

arrow lines straight and of equal length

Do not allow kinked, fuzzy curved lines.

Examiners report

[N/A]

48b. *[3 marks]*

Markscheme

$g=\ll\frac{GM}{r^2}=\frac{6.67\times10^{-11}\times2.0\times10^{30}}{(6.0\times10^{11})^2}\gg$ ***OR*** 3.7×10^{-4}Nkg^{-1}

$g_{net}=\ll 2g\cos\theta=2\times3.7\times10^{-4}\times\frac{\sqrt{6.0^2-3.4^2}}{6.0}=\gg 6.1\times10^{-4}\text{Nkg}^{-1}$

directed vertically down «page» ***OR*** towards midpoint between two stars ***OR*** south

Allow rounding errors.

Examiners report

[N/A]

49.

[1 mark]

Markscheme

D

Examiners report

[N/A]

50.

[1 mark]

Markscheme

D

Examiners report

Think proportionality.

Clearly the masses of the Sun and Moon do not change so we are only considering the distances. Considering Newton's inverse square law of gravitation, all that is needed is to switch the variables, r_S and r_M, and then square the ratio.

51a.

[3 marks]

Markscheme

gravitational provides centripetal force / gravitational provides force towards centre; (because radius is implied constant) (centripetal) force is constant;

at 90° to velocity (vector)/orbit/direction / *OWTTE* /
$\frac{GmM}{r^2} = \frac{mv^2}{r}$ (or re-arranged) and therefore speed is constant (and motion is uniform); } *(do not allow "inwards/centripetal" for this mark. The right angle must be explicit)*

Examiners report

Candidates were asked to outline the real meaning of "uniform circular motion". They were required to link the gravitational force acting on Phobos due to Mars (and the constancy of this force) to the dynamics of the force direction associated with the orbit and its consequences for the change in velocity (and lack of change in speed). Few managed to score all points with the majority managing to score 2 out of the 3 available.

51b.

[2 marks]

Markscheme

$v = \omega r$ and $\omega = \frac{2\pi}{T}$ combined; } *(allow approach from speed* $= \frac{s}{T}$, *do not allow approach from* $v^2 = ar$ or $f = \frac{1}{T}$)

$v = \left(\frac{2\pi r}{T} =\right) \frac{2\pi \times 9.4 \times 10^6}{7.7 \times 3600}$ ***or*** $2.1(3) \times 10^3\ (\mathrm{m\,s^{-1}})$;

Examiners report

This was a particularly simple “show that” question. Once again, examiners saw considerable numbers of answers that gave little information about the origin of the solution. As in past examinations, examiners saw much pure substitution without any explanation of its origin. This does not score well. It is best practice for candidates to present a full argument in calculations, and in “show that” and “deduce” questions it is essential.

51c.

[3 marks]

Markscheme

$m\frac{v^2}{r} = G\frac{mM}{r^2}$ ***or*** $F_c = F_G$;

$M = \frac{v^2 r}{G}$ ***or*** $\frac{(2.13\times10^3)^2\times9.4\times10^6}{6.67\times10^{-11}}$; *(allow power of ten error in this mark)*

$M = 6.4\times10^{23}$ (kg) from 2.13 ***or*** 5.6×10^{23} (kg) from 2;

*Award **[3]** for a bald correct answer.*

Examiners report

Candidates were on surer ground with the deduction of the mass of Mars. An algebraic starting point was allowed and many scored all 3 marks. However, a very large number failed to arrive at the correct numerical answer due to errors in powers of ten from the data provided.

52.

[1 mark]

Markscheme

D

Examiners report

[N/A]

53.

[1 mark]

Markscheme

C

Examiners report

[N/A]

54.

[1 mark]

Markscheme

D

Examiners report

[N/A]

55a. *[2 marks]*

Markscheme

gravitational potential energy is being gained;
this is at the expense of kinetic energy (and speed falls);

Examiners report

[N/A]

55b. *[2 marks]*

Markscheme

$\left(\text{acceleration} = \frac{(v-u)}{t} = \frac{4.25\times10^3-4.38\times10^3}{60} =\right)(-)\,2.17\left(\text{ms}^{-2}\right)$;

gravitational field strength = acceleration of rocket (=2.17 N kg^{-1}); } *(allow g = a in symbols)*

or

computes potential difference from KE per unit mass change (5.61 $\times 10^5$),
computes distance travelled (0.259 Mm), uses
$g = \frac{(-)\Delta V}{\Delta r}$;
g=($-$)2.17(ms^{-2});

Examiners report

[N/A]

55c. *[1 mark]*

Markscheme

the satellite has velocity/kinetic energy as it is orbiting with the space station;

Examiners report

[N/A]

56. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

57. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

58.

[1 mark]

Markscheme

A

Examiners report

[N/A]

59.

[1 mark]

Markscheme

B

Examiners report

60.

[1 mark]

Markscheme

D

Examiners report

There was much guessing here with even A and C being popular options. This would suggest that many candidates had not understood the situation – surely a fly near the hub of spinning bicycle wheel is going slower than one perched on the rim. So A and C should have been instantly discounted through the application of commonsense. Since the velocity and also the radius is changing from situation X to Y, it is easier to use the formula a = ω2r (where ω is constant) to ascertain that the acceleration at Y is greater. Alternatively, you can imagine that Y is on the outer edge of a fairground big wheel in order to realize that the forces upon you (and hence acceleration) will be greater.

61.

[1 mark]

Markscheme

A

Examiners report

[N/A]

62.

[1 mark]

Markscheme

B

Examiners report

[N/A]

63.

[1 mark]

Markscheme

D

Examiners report

This was well done by the candidates who correctly identified the origin of the force as the frictional force of the road on the tyres.

64a.

[2 marks]

Markscheme

direction changing;

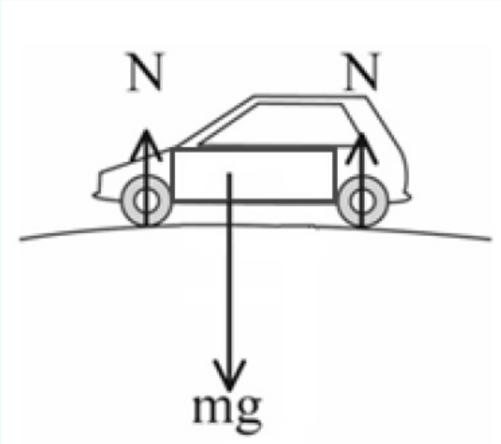
velocity changing so accelerating;

Examiners report

Most candidates failed to state that acceleration is the rate of change of velocity and that as velocity is a vector it has both magnitude and direction. With there being a change in direction the car accelerates. Many erroneously talked about there being a change of direction of the acceleration – the direction is always centripetal.

64b. *[2 marks]*

Markscheme



weight/gravitational force/mg/w/F_w/F_g and reaction/normal reaction/perpendicular contact force/N/R/F_N/F_R both labelled; *(do not allow "gravity" for "weight".)*

weight between wheels (in box) from centre of mass and reactions at both wheels / single reaction acting along same line of action as the weight;

Judge by eye. Look for reasonably vertical lines with weight force longer than (sum of) reaction(s). Extra forces (eg centripetal force) loses the second mark.

Examiners report

Few marked in reaction acting at each wheel and the weight acting from the centre of gravity. The weight needed to be larger than the combined reaction to give a resultant centripetal force (this is shown by the relative length of the lines). Most candidates were unconcerned about the point of application of the forces and often added spurious horizontal and/or centripetal forces. Centripetal forces, being the resultant of the other force, should not be marked in on free body diagrams like this.

64c. *[3 marks]*

Markscheme

$g = \frac{v^2}{r}$;
$v = \sqrt{50 \times 9.8}$;

22(ms^{-1});

*Allow **[3]** for a bald correct answer.*

Examiners report

The majority of candidates made a good attempt at calculating the maximum speed by equating the weight to the centripetal force (that is, in the limit there is no reaction force).

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