T6 *[200 marks]*

1. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

2. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

3. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

4. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

5. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

6a.

[1 mark]

Markscheme

upwards (or away from the Moon) is taken as positive / downwards (or towards the Moon) is taken as negative / towards the Earth is positive;

Examiners report

[N/A]

6b.

[6 marks]

Markscheme

(i) tangent drawn to curve at 0.80s;

correct calculation of gradient of tangent drawn;

-1.3 ± 0.1m s^{-1} ***or*** 1.3 ± 0.1m s^{-1} downwards;

or

correct coordinates used from the graph; substitution into a correct equation;

-1.3 ± 0.1m s^{-1} ***or*** 1.3 ± 0.1m s^{-1} downwards;

(ii) any correct method used;

correct reading from graph;

1.6 to 1.7 m s^{-2};

Examiners report

[N/A]

6c.

[4 marks]

Markscheme

values for masses, distance and correct G substituted into Newton's law;

see subtraction (*ie r* value = $3.84 \times 10^8 - 1.74 \times 10^6 = 3.82 \times 10^8$ m);

F=5.4 to 5.5 $\times 10^{-4}$ N / a=2.7 $\times 10^{-3}$ m s^{-2};

comment that it's insignificant compared with (0.2 × 1.63 =) 0.32 to 0.33 N / 1.63 m s^{-2};

Examiners report

[N/A]

6d.

[1 mark]

Markscheme

7.7 m s^{-1};

Examiners report

[N/A]

6e.

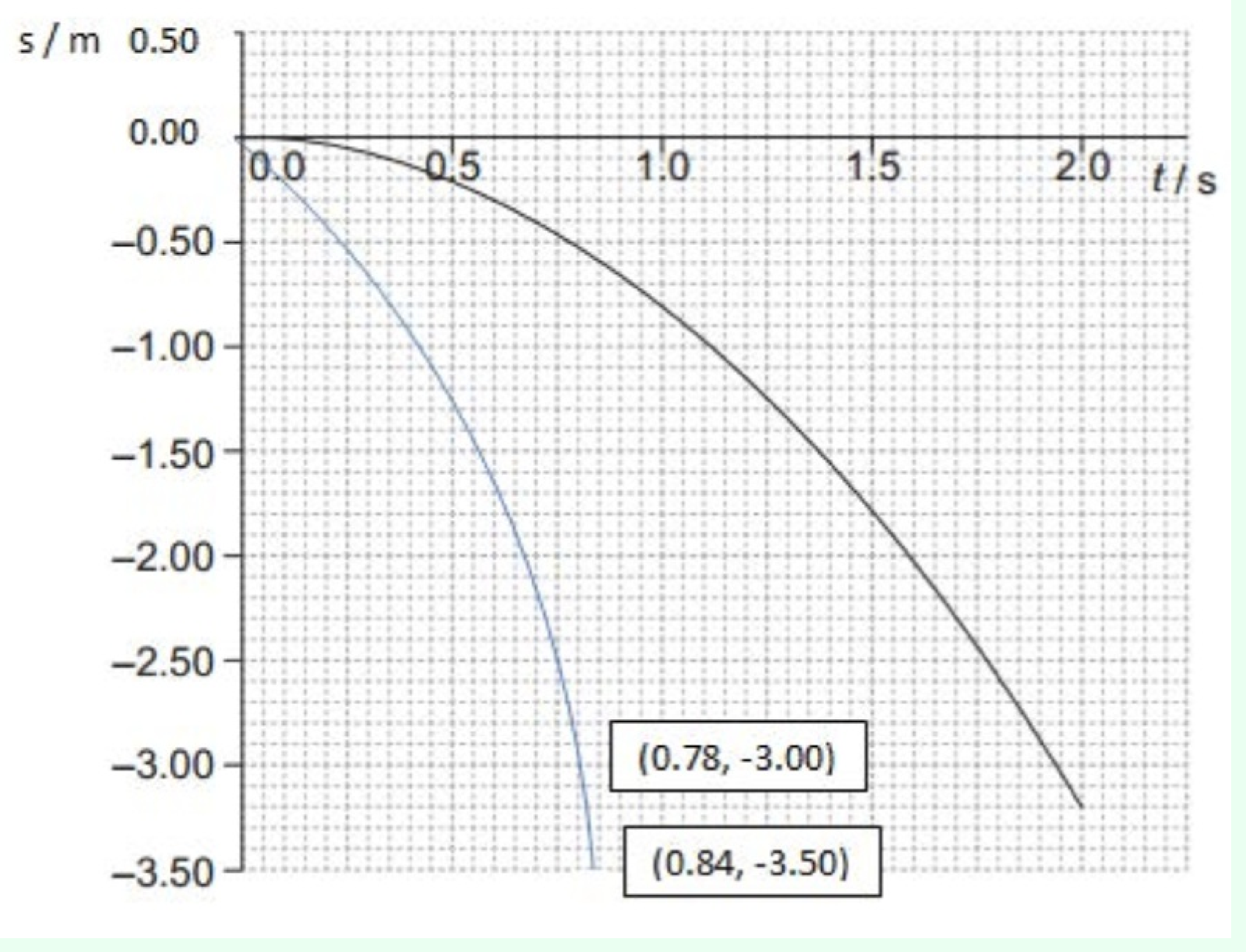
[3 marks]

Markscheme

curve permanently below Moon curve;

smooth parabola; *(judge by eye)*

line passing through s = −3.00 m, t = 0.78 s ***or*** s = −3.50 m, t = 0.84 s (±1mm);



Examiners report

[N/A]

6f.

[3 marks]

Markscheme

six half-lives occurred;

$\left(\left(\frac{1}{2}\right)^6 =\right) 1.6\%$ remaining;

98.4 / 98% decayed;

Examiners report

[N/A]

6g. *[4 marks]*

Markscheme

(i)(electron) anti-neutrino /
$\overline{v}$;

(ii) 46.95455 u − (46.95241 u + 0.00055 u) = 0.00159 u;

1.48 MeV;

(iii) does not account for energy of (anti) neutrino/gamma ray photons;

Examiners report

[N/A]

7a. *[2 marks]*

Markscheme

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

Examiners report

[N/A]

7b. *[2 marks]*

Markscheme

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

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]

7c. *[1 mark]*

Markscheme

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

Examiners report

[N/A]

8. *[1 mark]*

Markscheme

B

Examiners report

9. *[1 mark]*

Markscheme

B

Examiners report

As R is not defined in the stem it can be assumed it is irrelevant and therefore both C and D are incorrect. As we need to equate kinetic energy with potential energy to solve this problem, we can expect a factor of 2 from $\frac{1}{2}mv^2$. Hence B.

10. *[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.

11a. *[2 marks]*

Markscheme

(i) 2.0 ***or*** 0(ms^{-1});
(ii) 1.0 ***or*** 0(ms^{-1});

Examiners report

Most were able to identify the relative speeds. The markscheme was amended to also include answers in terms of velocity.

11b. *[6 marks]*

Markscheme

(i) her direction is changing;
hence her velocity is changing;
or
since her direction/velocity is changing;
a resultant/unbalanced/net force must be acting on her (hence she is accelerating);

(ii) arrow from Aibhe towards centre of merry-go-round;
Ignore length of arrow.

(iii) the force of the merry-go-round on Aibhe/her;

(iv) no force is acting on the upper body towards the centre of the circle / no centripetal force acting on the upper body (to maintain circular motion);
upper body (initially) continues to move in a straight line at constant speed/ velocity is tangential to circle;

Examiners report

i) This was well-answered with most identifying a change in direction and a change in velocity.

ii) The majority were able to show the direction of the centripetal acceleration.

iii) Few identified a force that would act on Aibhe. They did not realize that the centripetal force is the resultant of the forces acting.

iv) Few realized from the diagram that it would be difficult provide an inward directed force on Aibhe's upper torso. The consequence of this is that it would tend to continue to move in a direction which is tangential to the circle.

11c. *[2 marks]*

Markscheme

distance travelled by Euan=$4.0 \times 2\pi \times 1.5\,(= 37.70\text{m})$;
$W\,(= F_{av}d = 45 \times 37.70) = 1700\,(\text{J})$;

Examiners report

This was well done by many.

11d. *[5 marks]*

Markscheme

(i) Aibhe's period of revolution is the same as before;
from $v = \frac{2\pi r}{T}$, since *r* is halved, *v* is halved;
v=0.5(ms^{-1});
*Award **[3]** for a bald correct answer.*

(ii) $a\left(= \frac{v^2}{r}\right) = \frac{0.5^2}{0.75}$;
a=0.33(ms^{-2});
Allow ECF from (d)(i).
*Award **[2]** for a bald correct answer.*

Examiners report

i) Many scored three marks here.

ii) Most candidates were able to gain both marks.

12a. *[2 marks]*

Markscheme

power/energy per second emitted is proportional to surface area;
and proportional to fourth power of absolute temperature / temperature in K;
Accept equation with symbols defined.

Examiners report

The Stefan-Boltzmann law was poorly understood with few candidates stating that the absolute temperature is raised to the fourth power.

12b. *[2 marks]*

Markscheme

solar power given by $4\pi R^2 \sigma T^4$;
spreads out over sphere of surface area $4\pi d^2$;
Hence equation given.

Examiners report

This question was poorly done with few candidates substituting the surface area of the sun or the surface area of a sphere at the Earth's radius of orbit.

12c. *[2 marks]*

Markscheme

$\left(\frac{\sigma R^2 T^4}{d^2} =\right) \frac{5.7\times10^{-8}\times\left[7.0\times10^{8}\right]^2\times\left[5.8\times10^{3}\right]^4}{\left[1.5\times10^{11}\right]^2}$;

$=1.4\times10^{3}(\mathrm{Wm}^{-2})$;

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

Examiners report

Despite not being able to state or manipulate the Stefan-Boltzmann law most candidates could substitute values into the expression and calculate a result.

12d. *[2 marks]*

Markscheme

some energy reflected;
some energy absorbed/scattered by atmosphere;
depends on latitude;
depends on time of day;
depends on time of year;
depends on weather (*eg* cloud cover) at location;
power output of Sun varies;
Earth-Sun distance varies;

Examiners report

This question was well answered at higher level.

12e. *[2 marks]*

Markscheme

power radiated=power absorbed;

$T = \sqrt[4]{\frac{240}{5.7 \times 10^{-8}}}$ $(= 250\text{K})$;

Accept answers given as 260 (K).

Examiners report

To show the given value there is the requirement for an explanation of why the incident power absorbed by the Earth's surface is equal to the power radiated by the Earth, few candidates were successful in this aspect. Although most could substitute into the Stefan-Boltzmann equation they needed to either show that the fourth root was used or to find the temperature to more significant figures than the value given.

12f. *[3 marks]*

Markscheme

radiation from Sun is re-emitted from Earth at longer wavelengths;
greenhouse gases in the atmosphere absorb some of this energy;
and radiate some of it back to the surface of the Earth;

Examiners report

A surprising number of candidates could not explain the greenhouse effect. A common misunderstanding was that the Earth reflected radiation into the atmosphere and that the atmosphere reflected the radiation back to the Earth.

12g. *[4 marks]*

Markscheme

(i) gravitational force / gravitational attraction / weight; *(do not accept gravity)*

(ii) astronauts and spaceship have the same acceleration;
acceleration is towards (centre of) planet;
so no reaction force between astronauts and spaceship;

or

astronauts and spaceships are both falling towards the (centre of the) planet;
at the same rate;
so no reaction force between astronauts and spaceship;

Examiners report

(i) Most were able to state gravitational force, however a significant number stated gravity and consequently did not get the mark.

(ii) Many answers only discussed the astronauts and not the spaceship, missing points such as 'falling at the same rate' or 'with the same acceleration'.

12h. *[2 marks]*

Markscheme

gravitational force equated with centripetal force / $\frac{GmM}{r^2} = \frac{mv^2}{r}$;

$\Rightarrow v^2 = \frac{GM}{r} \Rightarrow \left(v = \sqrt{\frac{GM}{r}}\right)$;

Examiners report

This was well answered with candidates able to adequately show in their explanation where the expression comes from.

12i.

[4 marks]

Markscheme

(i) thermal energy is lost;
total energy decreases;

(ii) since *E* decreases, *r* also decreases;
as *r* decreases *v* increases / E_k increases so *v* increases;

Examiners report

ji) Most appreciated that the effect of the force would be to decrease the total energy.

jii) Very few appreciated that they should use the equations above to answer this part of the question. As a consequence, the most common answer discussed a decrease in kinetic energy and a decrease in speed.

13.

[1 mark]

Markscheme

A

Examiners report

[N/A]

14.

[1 mark]

Markscheme

A

Examiners report

[N/A]

15.

[1 mark]

Markscheme

A

Examiners report

[N/A]

16.

[1 mark]

Markscheme

A

Examiners report

[N/A]

17. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

18a. *[2 marks]*

Markscheme

direction changing;

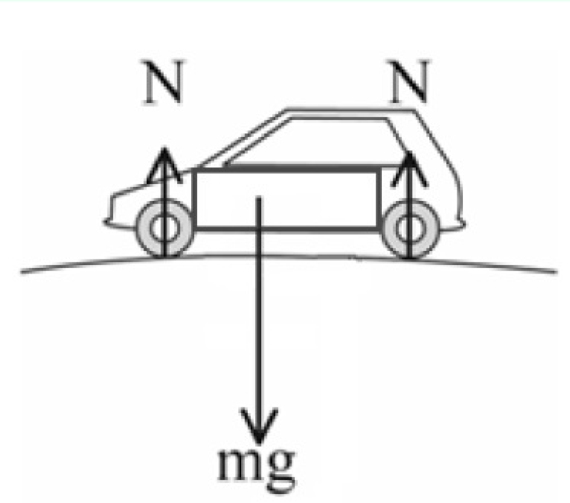
velocity changing so accelerating;

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.

18b. *[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.

18c. *[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).

19a. *[2 marks]*

Markscheme

the (attractive) force between two (point) masses is directly proportional to the product of the masses;
and inversely proportional to the square of the distance (between their centres of mass);
Use of equation is acceptable:
*Award **[2]** if all five quantities defined. Award **[1]** if four quantities defined.*

Examiners report

(a) Many candidates stated that the Newton's law force is proportional to the masses of the objects in question, rather than the product of the masses.

19b. *[3 marks]*

Markscheme

$G\frac{Mm}{R^2} = \frac{mv^2}{R}$ so $v^2 = \frac{Gm}{R}$;
$v = \frac{2\pi R}{T}$;
$v^2 = \frac{4\pi^2 R^2}{T^2} = \frac{Gm}{R}$;

or

$G\frac{Mm}{R^2} = m\omega^2 R$;
$\omega^2 = \frac{4\pi^2}{T^2}$;
$\frac{4\pi^2}{T^2} = \frac{GM}{R^3}$;
*Award **[3]** to a clear response with a missing step.*

Examiners report

This part was generally well done with most candidates coming to the correct outcome; too often steps were missed out in the derivations and this cost candidates mark. It is essential that they realise that a derivation must include every step. The presentation of this part left much to be desired in quite a large minority with mathematically incorrect statements being given.

19c. *[8 marks]*

Markscheme

(i) $R^3 = \frac{6.67\times10^{-11}\times5.97\times10^{24}\times6000^2}{4\times\pi^2}$;
R=7.13x10^6(m);
h=(7.13x10^6-6.37x10^6)=760(km);
*Award **[3]** for an answer of 740 with π taken as 3.14.*

(ii) clear use of $\Delta V = \frac{\Delta E}{m}$ and $V = -\frac{Gm}{r}$ **or** $\Delta E = GMm\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$;
one value of potential energy calculated (2.37×10^9 ***or*** 2.02×10^9);
3.5×10^8 (J);
*Award **[3]** for a bald correct answer.*
*Award **[2]** for 7.7x10^9. Award **[1]** for 7.7x10^{12}.*
*Award **[0]** for answers using mgΔh.*

(iii) increased;
further from Earth / closer to infinity / smaller negative value;
*Award **[0]** for a bald correct answer.*

Examiners report

(i) Most candidates were able to substitute values into the equation and rearrange it to find a value for R. Many then fail to subtract the radius of the Earth.

(ii) Very few candidates completed this part correctly. Confusion between potential and potential energy was common as were adding the height in kilometres to the radius of the Earth in metres. A sizeable minority of candidates attempted to use the mgh equation.

(iii) This part was quite well answered with most candidates realising that the increase in height meant an increase in potential energy. Several argued that the magnitude decreased but being a negative quantity this meant an increase.

20a. *[2 marks]*

Markscheme

the force between two (point) charges;
is inversely proportional to the square of their separation and (directly) proportional to (the product of) their magnitudes;

*Allow **[2]** for equation with F, Q and r defined.*

Examiners report

Many were able to state Coulomb’s law or to give the equation with explanations of the symbols. Some candidates however failed to define their symbols and lost marks.

20b. *[7 marks]*

Markscheme

(i) $F = \left(k\frac{q_1 q_2}{r^2} =\right) \frac{9\times10^{9}\times\left[1.6\times10^{-19}\right]^2}{4\times10^{-20}}$;
=5.8×10^{-9}(N);
*Award **[0]** for use of masses in place of charges.*

(ii) ($\frac{(b)(i)}{1.6\times10^{-19}}$ **or** 3.6 x 10^{10} (NC^{-1}) **or** (Vm^{-1});
(directed) away from the proton;
Allow ECF from (b)(i).
Do not penalize use of masses in both (b)(i) and (b)(ii) – allow ECF.

(iii) $H = \left(G\frac{m}{r^2} =\right) \frac{6.67\times10^{-11}\times1.673\times10^{-27}}{4\times10^{-20}} = 2.8\times10^{-18}\ (\mathrm{Nkg}^{-1})$;

$\frac{H}{E} = \frac{2.8\times10^{-18}}{3.6\times10^{10}}$ **or** 7.8×10^{-29}(Ckg^{-1});
(≈10^{28}Ckg^{-1})
Allow ECF from (b)(i).

(iv) 3.4(V);

Examiners report

(i) The electric force was calculated well by many.

(ii) The answer to (i) was well used to determine the magnitude of *E*. However, many candidates did not read the question and failed to state the direction of the field or gave it in an ambiguous way.

(iii) Calculations to show the order of magnitude of *H/E* were generally well done. The last step was often missing with the answer simply given as a fraction.

(iv) Many obtained this simple mark.

20c. *[6 marks]*

Markscheme

(i) power supplied per unit current / energy supplied per unit charge / work done per unit charge;

(ii) energy supplied per coulomb=$\frac{5.1\times10^{-19}}{1.6\times10^{-19}}$ ***or*** 3.19(V);
(≈3.2V)

(iii) pd across 5.0Ω resistor=$\left(\frac{4.0\times10^{-19}}{1.6\times10^{-19}} =\right) 2.5\ (\mathrm{V})$;
pd across *r*=(3.2-2.5=)0.70(V);

and

either

current in circuit=$\left(\frac{2.5}{5.0} =\right) 0.5\ (\mathrm{A})$;
resistance of *r*=$\left(\frac{0.70}{0.50} =\right) 1.4\ (\Omega)$;

or

resistance of *r*=$\frac{0.70}{2.5}\times5.0$;
=1.4(Ω);

or

3.2=0.5(R+*r*);
resistance of *r*=1.4(Ω);
*Award **[4]** for alternative working leading to correct answer.*
*Award **[4]** for a bald correct answer.*

Examiners report

(i) Many candidates gave confused or incorrect definitions of the emf of a cell. Previous comments in this report on the memorizing of definitions apply. Too many had recourse to the next part and used this idea in their answer.

(ii) This was well done.

(iii) A large number of candidates completed this calculation stylishly, generally explaining steps (or at least writing down the algebra) in a logical way. There were many correct and original solutions that gained full marks.

21.

[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.

22.

[1 mark]

Markscheme

B

Examiners report

[N/A]

23.

[1 mark]

Markscheme

D

Examiners report

[N/A]

24.

[1 mark]

Markscheme

B

Examiners report

[N/A]

25.

[1 mark]

Markscheme

A

Examiners report

[N/A]

26. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

27. *[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.

28. *[1 mark]*

Markscheme

B

Examiners report

29. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

30. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

31.

[1 mark]

Markscheme

C

Examiners report

32.

[1 mark]

Markscheme

D

Examiners report

[N/A]

33.

[4 marks]

Markscheme

(i) the force exerted on a small/test/point mass;
Do not allow bald "gravitational force".

(ii) the force exerted on a small/point/test positive charge;
*To award **[1]** "positive" is required.*
Do not allow bald "electric force".

(iii) the size/magnitude/value of the small/point mass;
Do not accept bald "mass".

(iv) the magnitude/size/value of the small/point/test (positive) charge;
Do not accept bald "charge".

Examiners report

In this part candidates were completely at a loss and could not state the meanings of the symbols in the definitions of gravitational or electric field strengths. This was a disappointing failure in what was meant to be an easy opener to the whole question.

34a.

[3 marks]

Markscheme

there is an attractive force;
between any two point/small masses;
proportional to the product of their masses;
and inversely proportional to the square of their separation;
Accept formula with all terms defined.

Examiners report

[N/A]

34b. *[2 marks]*

Markscheme

use of $g = \frac{F}{m}$ and $F = \frac{GmM}{R^2}$;

evidence of substitution/manipulation;

to get $g = \frac{GM}{R^2}$

Examiners report

[N/A]

34c. *[2 marks]*

Markscheme

$\frac{g_M}{g_E} = \frac{\frac{M_M}{R_M^2}}{\frac{M_E}{R_E^2}} \Rightarrow \frac{M_M}{M_E} = \frac{g_M}{g_E} \times \left[\frac{R_M}{R_E}\right]^2$;

$M_{\mathrm{M}} \left(= 0.38 \times 0.53^2 M_{\mathrm{E}}\right) = 0.11 M_{\mathrm{E}}$;

Examiners report

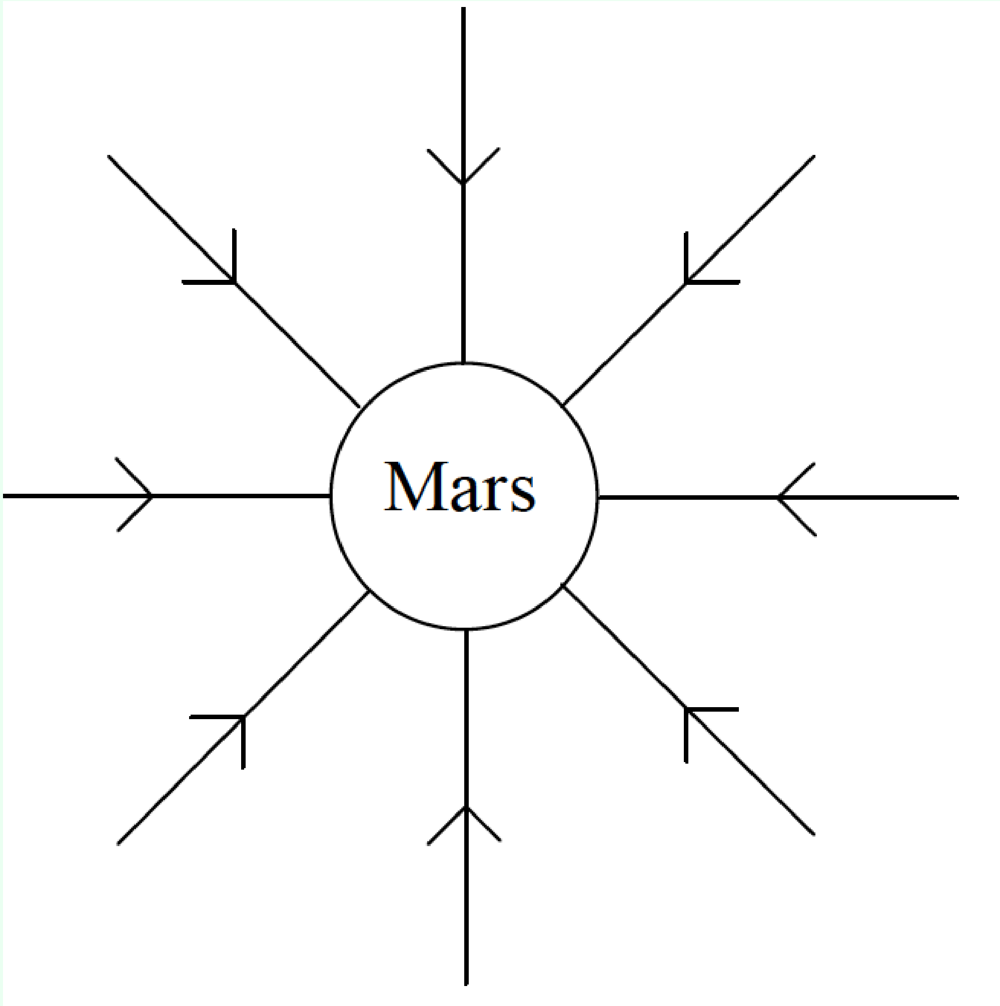
[N/A]

34d.

[3 marks]

Markscheme

(i) radial field with arrows pointing inwards;



(ii) field between A and B is not equal to field at surface;
acceleration is not constant between these two points;

Examiners report

[N/A]

35a.

[4 marks]

Markscheme

(i) the force exerted on a small/test/point mass;
Do not allow bald "gravitational force".

(ii) the force exerted on a small/point/test positive charge;
*To award **[1]** "positive" is required.*
Do not allow bald "electric force".

(iii) the size/magnitude/value of the small/point mass;
Do not accept bald "mass".

(iv) the magnitude/size/value of the small/point/test (positive) charge;
Do not accept bald "charge".

In part (a) only penalize lack of "small/test/point" once, annotate as ECF.
It must be clear that the mass/charge in (iii) & (iv) refer to the object in (i) and (ii).

Examiners report

In this part candidates were completely at a loss and could not state the meanings of the symbols in the definitions of gravitational or electric field strengths. This was a disappointing failure in what was meant to be an easy opener to the whole question.

35b.

[3 marks]

Markscheme

$E_p = \frac{e}{4\pi\varepsilon_0 r^2}$ and

$g_p = \frac{Gm_p}{r^2}$; *(both needed)*

$\frac{e}{4\pi\varepsilon_0 G m_p}\left(= \frac{9\times10^9\times1.6\times10^{-19}}{6.7\times10^{-11}\times1.7\times10^{-27}}\right)$;

$\approx 10^{28}$;

*Award **[2 max]** if response calculates ratio of force as this is an ECF from the first marking point (10^{39}) .*
*Award **[3]** for solution that correctly evaluates field strengths separately and then divides.*

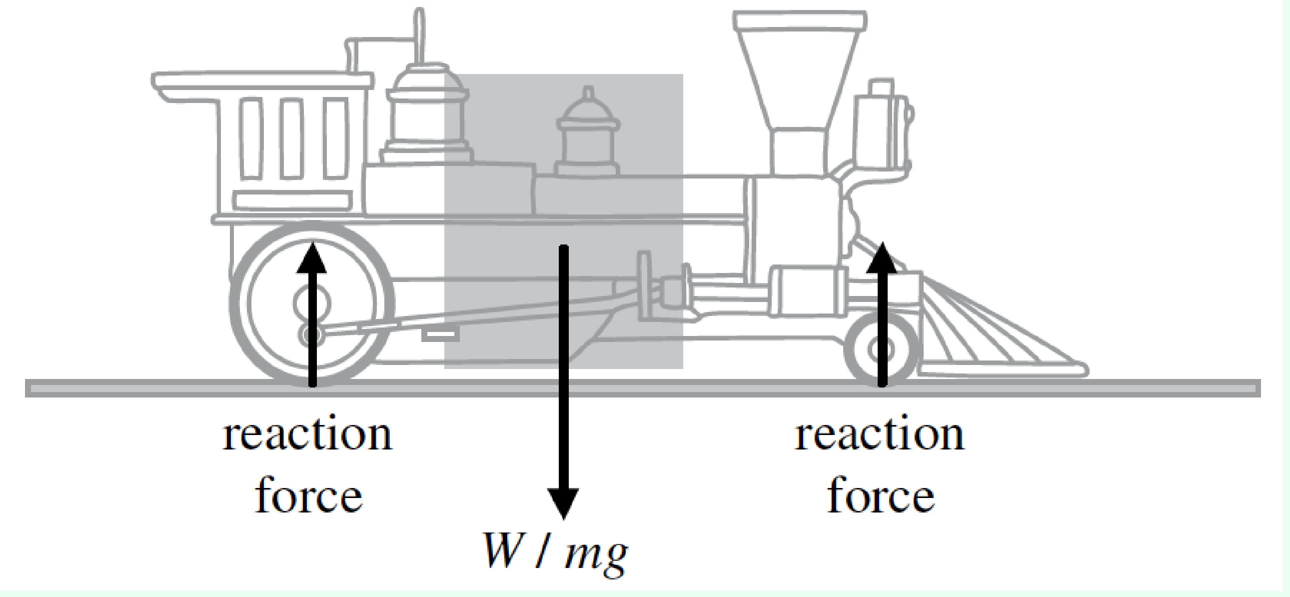
Examiners report

Following (a) candidates failed widely on this part too. They often had little idea which data to use (mass and charge were frequently confused) and sometimes the meaning of the constants in the equations failed them too. This was compounded by arithmetic errors to make a straightforward calculation very hard for many.

36a.

[3 marks]

Markscheme



The shaded box shows the acceptable range of position for W/mg.
single downward arrow labelled *W*/weight ***or*** *mg*/gravity force; *(do not allow gravity)*
two upward arrows labelled reaction/contact forces; *(do not allow for only one arrow seen)*
arrow positions as shown in diagram;

Examiners report

[N/A]

36b.

[2 marks]

Markscheme

horizontal forces have resultant of zero; *(must describe or imply horizontal force)*
valid statement linked to theory (*e.g.* Newton 1/Newton 2/conservation of momentum)
explaining why zero force results in constant velocity/zero acceleration;

Examiners report

[N/A]

36c.

[2 marks]

Markscheme

power =16×76000;
1.2 MW;

Examiners report

[N/A]

36d.

[2 marks]

Markscheme

acceleration= $\frac{16^2}{2\times1100}(=0.116)$;
$m=\left(\frac{7.6\times10^4}{0.116}=\right)6.5\times10^5\mathrm{kg}$;
*Award **[2]** for a bald correct answer.*

or

use of *Fs*=$\frac{1}{2}mv^2$;
$m=\left(\frac{2\times7.6\times10^4\times1100}{16^2}=\right)6.5\times10^5\mathrm{kg}$;
*Award **[2]** for a bald correct answer.*

Examiners report

[N/A]

36e.

[5 marks]

Markscheme

(i) 57 kN;

(ii) $F_8=\frac{F_{16}}{2^3}$;
F_8=7.1(kN);
total force =19+7.1(kN);
=26 kN;
*Award **[4]** for a bald correct answer.*

or

$k=\left(\frac{57\times10^3}{16^3}\right)=13.91$;
F_8=(13.91×8^3)=7.1(kN);
total force=19+7.1(kN);
=26 kN;
*Award **[4]** for a bald correct answer.*

Examiners report

[N/A]

36f.

[3 marks]

Markscheme

direction of engine is constantly changing;
velocity is speed + direction / velocity is a vector;
engine is accelerating as velocity is changing;
*Award **[0]** for a bald correct answer.*

or

centripetal force required to maintain circular motion;
quotes Newton 1/Newton 2;
so engine is accelerating as a force acts;
*Award **[0]** for a bald correct answer.*

Examiners report

[N/A]

37a.

[2 marks]

Markscheme

force is proportional to product of masses and inversely proportional to square of distance apart;
reference to point masses;

Examiners report

[N/A]

37b.

[3 marks]

Markscheme

(i) order of 1 cm;

(ii) $3\times10^{8}\times67\times10^{-3}$;
2.0×10^{7}m;

Examiners report

[N/A]

37c. *[8 marks]*

Markscheme

(i) force required towards centre of Earth to maintain orbit;
force means that there is an acceleration / *OWTTE*;

or

direction changes;
a change in velocity therefore acceleration;

(ii) uses= $\frac{GM}{r^2}$ ***or*** $\frac{6.7\times10^{-11}\times6.0\times10^{24}}{\left[2.6\times10^{7}\right]^{2}}$;
$0.57 Nkg^{-1}$; (allow ms^{-2})

(iii) $v=\sqrt{0.57\times\left(2.0\times10^{7}+6.4\times10^{6}\right)}$ by equating $\frac{v^2}{r}$ and *g*;
$3900 ms^{-1}$;

(iv) $T=2\pi\frac{2.6\times10^{7}}{3900}$;
11.9 hours;

Examiners report

[N/A]

38. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

39. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

40. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

41a. *[4 marks]*

Markscheme

(i) $v=\sqrt{\frac{2eV}{m}}$;

$v=\sqrt{\frac{2\times 1.6\times 10^{-19}\times 250}{9.1\times 10^{-31}}}$;

$=9.4\times 10^{6}\text{ms}^{-1}$

(ii) $evB=m\frac{v^2}{r}$;

$r=\frac{9.1\times 10^{-31}\times 9.4\times 10^{6}}{1.6\times 10^{-19}\times 0.12}$;

$=4.5\times 10^{-4}\text{m}$

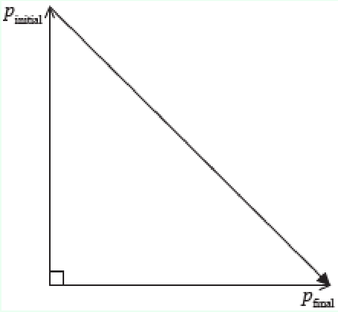
Examiners report

[N/A]

41b. *[3 marks]*

Markscheme

(i) vector as shown;



(ii) $\Delta p=\sqrt{\left[8.6\times 10^{-24}\right]^2+\left[8.6\times 10^{-24}\right]^2}$;

$=1.2\times 10^{-23}\text{Ns}$

(iii) $F\left(=\frac{\Delta p}{\Delta t}=\frac{1.2\times 10^{-23}}{7.5\times 10^{-11}}\right)=1.6\times 10^{-13}\text{N}$;

Examiners report

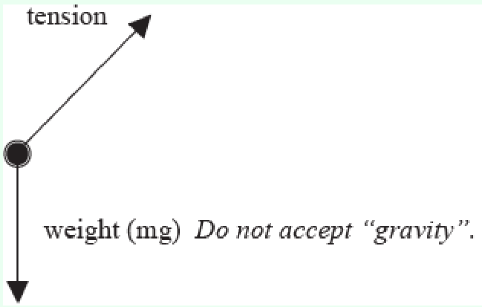
[N/A]

42a.

[4 marks]

Markscheme

(i) ***[1]*** each for correct arrow <u>and</u> (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]

42b.

[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]

43a.

[1 mark]

Markscheme

because the force is always at right angles to the velocity / motion/orbit is an equipotential surface;
Do not accept answers based on the displacement being zero for a full revolution.

Examiners report

[N/A]

43b.

[4 marks]

Markscheme

(i) equating gravitational force $\frac{GMm}{r^2}$;

to centripetal force $\frac{mv^2}{r}$ to get result;

(ii) kinetic energy is $\frac{GMm}{2r}$;

addition to potential energy $-\frac{GMm}{r}$ to get result;

Examiners report

[N/A]

43c.

[2 marks]

Markscheme

the total energy (at the new orbit) will be greater than before/is less negative;
hence probe engines must be fired to produce force in the direction of motion / positive work must be done (on the probe);
*Award **[1]** for mention of only potential energy increasing.*

Examiners report

[N/A]