Markscheme-Topic 2: Mechanics

1. C
2. A
3. B
4. B
5. A
6. A
7. B
8. C
9. C
10. C
11. A
12. C
13. B
14. D
15. A
16. A
17. A
18. D
19. A
20. B
21. C
22. D
23. C
24. D
25. B
26. B
27. D
28. B
29. C
30. D
31. B
32. C
33. C
34. A
35. B
36. B
37. C
38. A
1. Linear motion
   (a) change in velocity / rate of change of velocity;
       per unit time / with time; (ratio idea essential to award this mark)  

   (b) (i) acceleration is constant / uniform;  
         (ii) \[ t = \frac{2s}{u+v} \text{ and } t = \frac{(v-u)}{a}; \]
         clear working to obtain \( v^2 = u^2 + 2as; \)  

   (c) (i) \[ 1.96 = \frac{1}{2} \cdot 9.81 \cdot t^2; \]
        \( t = 0.632 \text{s}; \)  

   (ii) time to fall (1.96 + 0.12)m is 0.651s;
        shutter open for 0.019s;  

   *If the candidate gives a one significant digit answer treat it as an SD-1. Award [0] if the candidate uses \( s = \frac{1}{2} \cdot at^2 \) and \( s = 12 \text{cm}. \)
2. (a) (i) \[ h = \frac{v^2}{2g}; \]

\[ \text{to give } h = 3.2 \text{ m}; \]

(ii) 0.80 s;

(b) time to go from top of cliff to the sea = 3.0 – 1.6 = 1.4 s;
recognize to use \[ s = ut + \frac{1}{2} at^2 \] with correct substitution,
\[ s = 8.0 \times 1.4 + 5.0 \times (1.4)^2; \]

\[ \text{to give } s = 21 \text{ m}; \]

Answers might find the speed with which the stone hits the sea from \( v = u + at, (42 \text{ m s}^{-1}) \) and then use \( v^2 = u^2 + 2as. \)

3. (a) \[ v_V = 8.0 \sin 60 = 6.9 \text{ m s}^{-1}; \]
\[ h = \frac{v^2}{2g}; \]

\[ \text{to give } h = 2.4 \text{ m}; \]

Award [II] if \( v = 8.0 \text{ m s}^{-1} \) to get \( h = 3.2 \text{ m} \) is used.

(b) \[ v_H = 8.0 \cos 60; \]
\[ \text{range} = v_H t = 8.0 \cos 60 \times 3 = 12 \text{ m}; \]

Award [II] if \( v = 8.0 \text{ m s}^{-1} \) to get \( R = 2.4 \text{ m} \) is used.

4. (a) use \( \frac{1}{2}mv^2 + mgh = \frac{1}{2}mv^2 \) or some statement that conservation of
energy is used;
\[ = \frac{1}{2} (15)^2 + 700 = \frac{1}{2} V^2; \]

\[ \text{to give } V = 40 \text{ ms}^{-1} \]

(b) appreciate that the horizontal velocity remains unchanged;

so that \( \theta = \cos^{-1} \frac{15}{40} = 68^\circ; \)

Accept alternative methods of solutions for (a) and (b) based on vertical
component of velocity calculations and vector addition of components.

5. (a) (i) \[ \frac{40}{5.0} = 8.0 \text{ m s}^{-1} \]

Accept use of other values leading to the same answer.
(ii) \(v_y = 0 = u_{0y} - 10 \times 2.5;\)
\[u_{0y} = 25 \text{ m s}^{-1};\]
Accept use of other values leading to the same answer.

(iii) the x and y components of displacement at 3.0 s are 24 m, 30 m;
so the magnitude is \(\sqrt{24^2 + 30^2} = 38 \text{ m}\)

(b) maximum height reached is less;
asymmetric with shorter range;

6. (a) zero;

(b) resultant vertical force from ropes = \((2.15 \times 10^3 - \text{weight}) = 237\text{N};\)
equating their result to \(2T \sin 50;\)
\[\text{ie } 2T \sin 50 = 237\]
calculation to give \(T = 154.7\text{N} \approx 150\text{N};\)
Accept any value of tension from 130 N to 160 N. Award [2] for missing factor of 2 but otherwise correct i.e 309 N.

(c) correct substitution into \(F = ma;\)
to give \(a = \frac{237}{1.95 \times 10^2} = 1.21 \text{ ms}^{-2};\)
Watch for ecf.

NB Depending on value of \(g\) answer will vary from 1.0(3) ms\(^{-2}\)
to 1.2(3) ms\(^{-2}\) all of which are acceptable.

(d) statement that air friction increases with increased speed seen / implied;
in 10 seconds friction goes from 0 N to 237 N / force increases from zero until it equals the net upward accelerating force;

7.

(a) [1] for each correctly drawn and named force [3 max]
8.

(a) nature of the surfaces; normal reaction; relative motion of the surfaces; [2 max]

(b) friction is the frictional force between an object and a surface / two surfaces; static friction is (the frictional force) when the object/surfaces are at rest; dynamic friction is (the frictional force) when the object is sliding / one of the surfaces is sliding / moving with respect to the other; some additional comment e.g. friction varies from zero to maximum / maximum value of static friction always greater than kinetic friction; [3 max]

Award [1 max] for an answer such as “friction force on an object at rest and friction force on a moving object”. Some appreciation that it is friction between two surfaces is required.

(c) \( \mu_s = \frac{7.2}{12} = 0.60 \); [1]

(d) it will accelerate; since the coefficient of dynamic friction is less than coefficient of static friction; therefore, frictional force acting is less than 7.2 N / a net force greater than zero acting on the block. [3]

Award [9] for a bald statement or incorrect reasoning. [9]

9.

(a) mass \( \times \) velocity; 1

(b) (i) momentum before = \( 800 \times 5 = 4 \, 000 \, N \, s \); momentum after = \( 2 \, 000v \); conservation of momentum gives \( v = 2.0 \, m \, s^{-1} \); [3]

(ii) KE before = \( 400 \times 25 = 10 \, 000 \, J \) KE after = \( 1 \, 000 \times 4 = 4 \, 000 \, J \); loss in KE = \( 6 \, 000 \, J \); [2]
(c) transformed / changed into; heat (internal energy) (and sound); 2

Do not accept “deformation of trucks.”

10. (a) Note: for part (i) and (ii) the answers in brackets are those arrived at if 19.3 is used as the value for the height.

(i) height raised = 30 \( \sin 40 = 19 \) m;
    gain in PE = \( mgh = 700 \times 19 = 1.3 \times 10^4 \) J (1.4 \( \times 10^4 \) J); 2

(ii) \( 48 \times 1.3 \times 10^4 = 6.2 \times 10^5 \) J (6.7 \( \times 10^5 \) J); 1

(iii) the people stand still / don’t walk up the escalator
    their average weight is 700 N / ignore any gain in KE of the people; 1 max

(b) power required = \( \frac{(6.2 \times 10^5)}{60} \) = 10 kW (11kW);

\[ Eff = \frac{P_{out}}{P_{in}}, P_{in} = \frac{P_{out}}{Eff}; \]

\[ P_{in} = 14 \text{ kW (16 kW)}; \]

11. (a) momentum of object = \( 2 \times 10^3 \times 6.0; \)
    momentum after collision = \( 2.4 \times 10^3 \times v; \)
    use conservation of momentum, \( 2 \times 10^3 \times 6.0 = 2.4 \times 10^3 \times v; \)
    to get \( v = 5.0 \text{ m s}^{-1}; \) 4

\[ \text{Award } [2 \text{ max}] \text{ for mass after collision } = 400 \text{ kg and } v = 30 \text{ m s}^{-1}. \]

(b) KE of object and bar + change in PE = \( 1.2 \times 10^3 \times 25 + 2.4 \times 10^3 \times 10 \times 0.7533; \)
    use \( \Delta E = Fd, 4.8 \times 10^4 = F \times 0.75; \)
    to give \( F = 64 \text{ kN}; \)

\[ \text{Award } [2 \text{ max}] \text{ if PE missed } F = 40 \text{ kN}. \]

or

\[ a = \frac{v^2}{2s}; \]

\( F - mg = ma; \)
    to give \( F = 64kN; \) 3

\[ \text{Award } [2 \text{ max}] \text{ if } mg \text{ missed}. \]