1. (a) $F \cos 25 = 470$;
520 N; 2

(b) (i) work done – 470×2500;
1.2 MJ;
*Award **[1 max]** for power of 10 error.* 2

(ii) ;
270 W; 2
Allow correct solution from power = $F \times v$.

(c) work still done against friction ;
work done raising load vertically / increase in gravitational potential energy; 2

[8]

2. D

[1]

3. (a) attempt to equate gpe and ke;
v = ; 2
11 m s^{-1}
*Award **[0]** for use of $v^2 = 2as$. Allow use of $g = 10\ N\ kg^1$*

(b) F = ;
40 N ; 2

(c) (i) ball accelerates towards centre of circular path / *OWTTE*;
therefore force towards centre / upwards;
that adds to tension; 3

(ii) $F = 8.9$ N;
weight = ($mg = 0.55 \times 0.98$) = 5.4N;
total = 14N; 3
Allow use of $g = 10\ N\ kg^{-1}$.

[10]

4. (a) when a force acts on a body an equal and opposite force acts on another body / in the interaction between two bodies A and B, the force that A exerts on B is equal and opposite to the force that B exerts on A; 1

(b) forces on Earth and book are equal and opposite / no external

force acts on the system;
changes in momentum of Earth and book are equal and opposite /
net force on Earth-book system is zero;
hence momentum of Earth-book system stays the same/is always
zero and so is conserved; 3

(c) (i) v = ;
= 5.6 m s^{-1} 1

(ii) calculation of speed of ball and spike $3.5 \times 5.6 = 4.3V$;
V = 4.6 m s^{-1};
KE before = [3.5×5.6^2] KE after = [4.3×4.56^2];
energy dissipated = 54.88 – 44.70 ;
= 10 J 4
Accept 9.4 J if 4.6 used for V.

(d) F = ;
$\Delta KE = 0.50 \times 4.3 \times 4.6^2 = 45$ (J);
$F = 6.2 \times 10^2$ N; 3

or

a = ;
$a = 1.45 \times 10^2$ m s^{-2};
$F = ma = 4.3 \times 1.45 \times 10^2 = 6.2 \times 10^2$ N;

(e) time = ;
work = ($3.5 \times 1.6 \times 9.8$ =) 55(J);
time = 3.1s; 3

[15]

5. D

[1]

6. (a) the total momentum of a system is constant;
provided external force does not act; 2

or

the momentum of an isolated/closed system;
is constant;
*Award **[1]** for momentum before collision equals collision afterwards.*

(b) (i) initial momentum = $2.0 \times 10^{-3} \times 140$;
final speed = ;
= 4.8 m s^{-1} 2
Watch for incorrect mass values in equation.

(ii) initial kinetic energy of pellet + clay block = mv^2;
$0.5 \times 0.058 \times 4.8^2$ (= 0.67 J);
force = ;
= 0.24 N; 4

or

use of appropriate kinematic equation with consistent sign
usage *e.g.* a = ;
a = ;
F = ;
= 0.24 N;

(c) kinetic energy of pellet is transferred to kinetic energy of clay block;
and internal energy of pellet and clay block;
clay block loses kinetic energy as thermal energy/heat; 3

(d) v = ;
= 4.1 m s^{-1};
Allow g = 10 m s^{-2} answer 4.1 m s^{-2} 2

[13]

7. (a) equation is for constant acceleration;
force varies and so acceleration changes; 2

(b) (i) average force = 2100 N;
acceleration = = 6.6×10^4 m s^{-2} 2

(ii) uses area under the line;
1 square is equivalent to 0.125Ns;
area is 68 → 72 squares;
(to give momentum change 8.5 → 9.0Ns) 3

(c) (i) use of $\Delta p = m\Delta v$;
v = 280 m s^{-1}; 2
Allow value for momentum change from (b)(ii).

(ii) use of power = ;
change in kinetic energy = $\times 0.032 \times 280^2$;
= power = 0.26 MW; 3

or

use of E = ;
;
power = 0.24 MW;
*Award **[0]** for solution from $P = Fv$.*

(d) N3 states that action and reaction are equal and opposite;
so force on gun and force on bullet are action and reaction pair;
so force on gun is opposite direction to bullet/backwards; 3

[15]

8. (a) $T = mg$ (= 770 × 9.8) = 7500N; 1
Accept use of g = 10 to yield 7.7kN.

(b) (i) (conservation of energy) leading to v = ;
= 5.6 m s^{-1} ***or*** 5.7 m s^{-1}; 2
Accept use of g = 10. Do not allow solutions from $v^2 = u^2 + 2as$.

(ii) use of ;
= 2000(N);
T = (2000 + 7500 =) 9500N; 3

(c) (i) impulse / change in momentum; 1

(ii) use of $F\Delta t = \Delta p$ ***or*** $\Delta p = 5.60 \times 770 = 4312$(Ns);
$F_{max} \times 0.15 = 4312$;
F_{max} = 57kN; 3

[10]