1)

a) Since there is no friction, energy is conserved.

$$E_A = E_C$$

$$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$$

$$v = \sqrt{2gh} \Rightarrow \underline{v = 6.6 \text{ m/s}}$$

b) Labeling the point corresponding to the location of block at maximum compression by D:

$$E_C = E_D$$

$$\frac{1}{\cancel{2}}mv^2 = \frac{1}{\cancel{2}}kx^2$$

$$x = v\sqrt{\frac{m}{k}} \Rightarrow \underline{x = 0.18 \text{ m}}$$

c)

$$f_k = \mu_k . N \qquad W_f = -f_k d$$

$$= \mu_k . m . g \qquad = -\mu_k m g d \Rightarrow \underline{W_f = -16 \text{ J}}$$

d) The net force on block from point B and C is f_k. So the work done by f_k, i.e. W_f, is equal to change in kinetic energy.

$$\Delta K = W_f$$

$$\frac{1}{2}mv'^2 - \frac{1}{2}mv^2 = W_f$$

$$v' = \sqrt{\frac{2W_f}{m} + v^2} \Rightarrow \underline{v' = 4.6 \text{ m/s}}$$

e)

$$E_C = E_D$$

$$\frac{1}{2}mv'^2 = \frac{1}{2}kx'^2$$

$$x' = v'\sqrt{\frac{m}{k}} \Rightarrow \underline{x' = 0.12 \text{ m}}$$

(a) $v = 6.6$ m/s

(b) $x = 0.18$ m

(c) $W_f = -16$ J

(d) $v' = 4.6$ m/s

(e) $x' = 0.12$ m

2)

(a) $E_{tot} = U + \frac{1}{2} m v^2$

$= -12\,J + \frac{1}{2}\, 1.0 \times 10^{-3}\,kg \cdot (45.0\,m/s)^2$

$\underline{E_{tot} = -11\,J}$

(b) Turning points r_0 are such that $U(r_0) = E_{tot}$. So roughly they are

$\underline{r_0 = 3nm \text{ \& } 7nm}$

(c) Motion is allowed when $E_{tot} \geq U$. So motion is allowed for

$3nm \leq r \leq 7\,nm$

(d) $F = -\frac{dU}{dx}$

$F = 0 \Rightarrow \frac{dU}{dx} = 0$ This is satisfied at the minimum for U

i.e. $\underline{r \simeq 5nm}$ and at the maximum

i.e. $\underline{r \geq 17\,nm}$

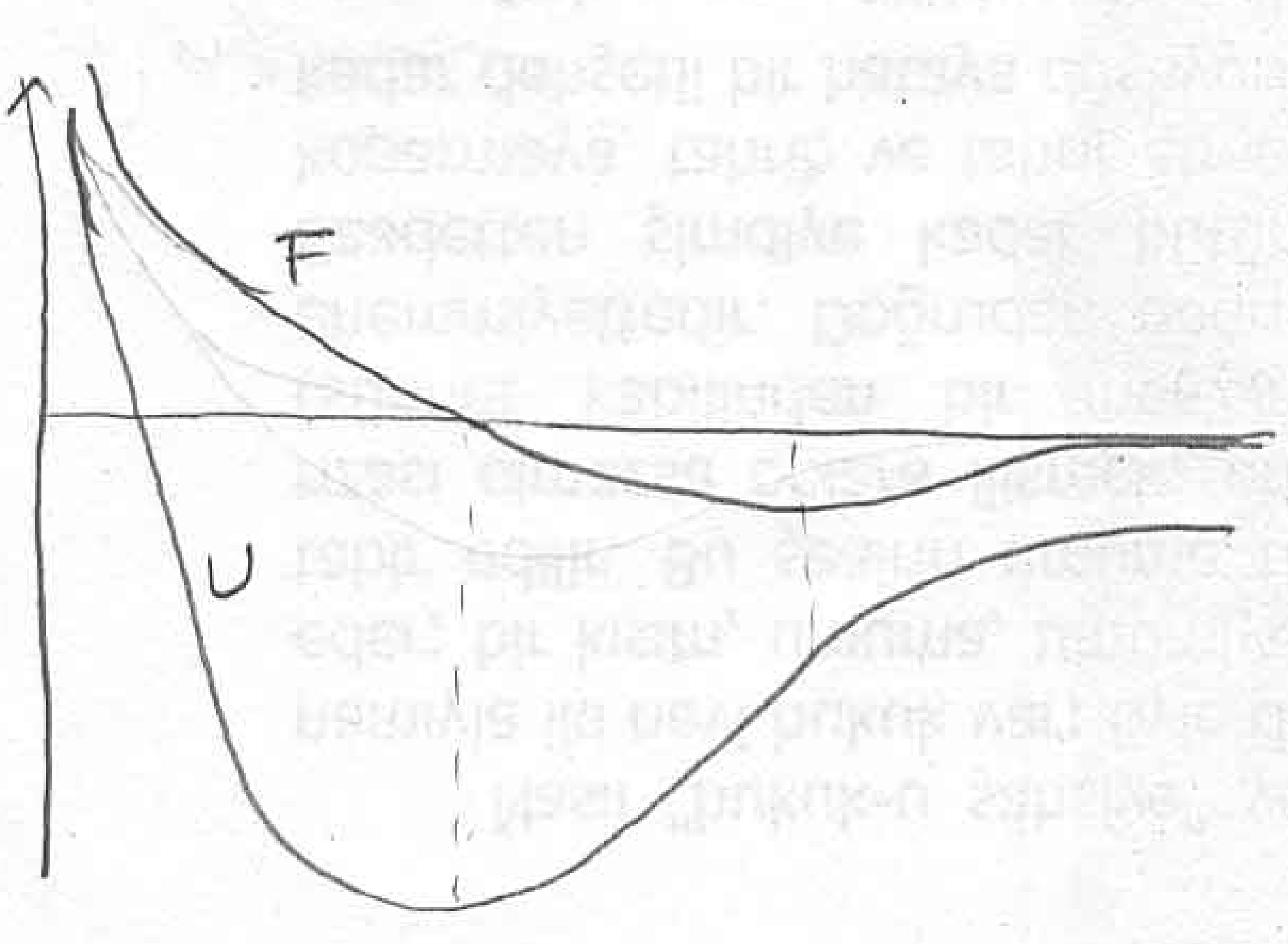
(e) For the particle to escape infinity, we should have

$E_{tot} \geq -1.5\,J$

$U(r = 5.0\,nm) + \frac{1}{2} m v_{min}^2 = -1.5\,J$

$-12\,J + \frac{1}{2} m v_{min}^2 = -1.5\,J \Rightarrow \underline{v_{min} = 1.4 \times 10^2\ m/s}$

(f)



a. $E = -11\,J$

b. Turning points: 3nm & 7 nm

c. $3nm \leq r \leq 7nm$

d. $F = 0$ at $r \simeq 5nm$ & $r \geq 17nm$

e. $v_{min} = 1.4 \times 10^2\ m/s$

3)

a) $\vec{p}_M = m_M \vec{v}_M = 70\ kg \cdot 6.2\ km/h \cdot \hat{i} = 4.3 \times 10^2\ kg\ km/h\ \hat{i}$

$\vec{p}_J = m_J \vec{v}_J = 55\ kg \cdot 7.8\ km/h\ \hat{j} = 4.3 \times 10^2\ kg\ km/h\ \hat{j}$

$\vec{p}_{couple} = m_{couple} \vec{v}_{couple} = (55\ kg + 70\ kg)\ \vec{v}_{couple} = 1.25 \times 10^2\ \vec{v}_{couple}$

Momentum is conserved,

$\vec{p}_M + \vec{p}_J = \vec{p}_{couple}$

$4.3 \times 10^2\ kg\ km/h\ \hat{i} + 4.3 \times 10^2\ kg\ km/h\ \hat{j} = 1.25 \times 10^2\ kg\ \vec{v}_{couple}$

$\vec{v}_{couple} = (\overset{3.472}{3.5}\ \hat{i} + \overset{3.43}{3.4}\ \hat{j})\ km/h$

$\theta = \arctan\left(\frac{3.4}{3.5}\right) \Rightarrow \underline{\theta = 45^\circ}$

b) $|v_{couple}| = \sqrt{(3.5)^2 + (3.4)^2}\ km/h \Rightarrow \underline{v_{couple} = 4.9\ km/h}$

c) $K_i = \frac{1}{2} m_M v_M^2 + \frac{1}{2} m_J v_J^2 = 3.0 \times 10^3\ kg\ km^2/h^2$

$K_f = \frac{1}{2} m_{couple} v_{couple}^2 = 1.5 \times 10^3\ kg\ km^2/h^2$

$\frac{|\Delta K|}{K_i} = \frac{|K_f - K_i|}{K_i} = \frac{1}{2}$ //

a) $\theta = 45^\circ$

b) $|\vec{v}| = 4.9\ km/h$

c) Fractional change $= \frac{1}{2}$

4)

a) Center of mass of each sphere is at its center. So

$$X_1 = R_1 = \underline{1.0 m}$$

$$X_2 = 2R_1 + R_2 = 2 \times 1.0 m + 0.3 \times 1.0 m = \underline{2.3 m}$$

$$X_3 = 2R_1 + 2R_2 + R_3 = 2 \times 1.0 m + 2 \times 0.3 \times 1.0 m + 0.3 \times 0.3 \times 1.0 m = \underline{2.7 m}$$

b) $$X_{cm} = \frac{M_1 X_1 + M_2 X_2 + M_3 X_3}{M_1 + M_2 + M_3}$$

$$= \underline{1.04 m}$$

c) $$F = M \cdot A$$

$$\cancel{M} g = \cancel{M} A$$

$$A = g$$

$$\underline{A = 9.8 m/s^2}$$