These are *answers* to the exam questions, not complete solutions. Answers provided to questions requiring explanations do not represent complete solutions, and would not necessarily receive the full marks allocated on the exam paper. Many marks are given on the exam for ‘working’ (i.e. for showing that you understand the relevant physics), and a numerical answer alone is not always sufficient to gain full marks.

1. (a)
   (i) Diagram required. $\ddot{a} = \frac{d_1}{m} \hat{x} + \frac{d_2 - mg}{m} \hat{y} = -0.631 \hat{x} - 4.23 \hat{y}$.
   (ii) 3.23 s.
   (iii) 13.8 m/s.

   (b)
   (i) 10 m/s.
   (ii) $1.9 \times 10^{-2}$ m/s$^2$.
   (iii) 18 m/s.

2. (a) The bulb should be positioned at the centre of mass, a distance $x_{CM} = \frac{m}{M + m} d$ to the right of mass $M$ on the diagram.

   (b)
   (i) $J_0$ and $J_1$ units: Newton. $p$ units: m$^{-1}$.
   (ii) $x_{\text{min}} = \frac{\pi}{p}$.
   (iii) Graph required. (Note: the location of $F(x) = 0$ cannot be determined because the relative magnitudes of $J_0$ and $J_1$ are not specified.)
   (iv) $W = J_0 \frac{\pi}{p}$.
   (v) $v = \sqrt{\frac{2J_0 \pi}{M p}} + v_0^2$.

3. (a) $\mu_s = \tan \theta$. In order to determine the coefficient of kinetic friction, we would need to measure the acceleration of the block down the slope while it was sliding. Alternatively, the slope could be adjusted until the block slid down at constant velocity, in which case we would have $\mu_k = \tan \theta$, with $\theta$ less than it was for the static friction case.

   (b)
   (i) 34.8°.
   (ii) Diagram required.
   (iii) $F_k = Ma_{cm} / 2$. 
4.
(a) 
(i) 0.359 m/s².
(ii) 2.44 × 10³ m/s².
(iii) 93.2 m.

(b) 
(i) 343 kg m²/s.
(ii) Yes. I = 2.4 × 10³ kg m².
(iii) L_f = 405 kg m²/s. ω_f = 0.143 rad/s.

5.
(a) 
(i) Graph required.
(ii) Graph required.

(b) 
(i) For x > λ/4:
\[ D_o(x,t) = A \sin \left[ k \left( x + \frac{\lambda}{4} \right) - \omega t \right] \], \[ D_f(x,t) = A \sin \left[ k \left( x - \frac{\lambda}{4} \right) - \omega t \right] \]
For x < -λ/4:
\[ D_o(x,t) = A \sin \left[ k \left( x + \frac{\lambda}{4} \right) + \omega t \right] \], \[ D_f(x,t) = A \sin \left[ k \left( x - \frac{\lambda}{4} \right) + \omega t \right] \]
For -λ/4 < x < λ/4:
\[ D_o(x,t) = A \sin \left[ k \left( x + \frac{\lambda}{4} \right) - \omega t \right] \], \[ D_f(x,t) = A \sin \left[ k \left( x - \frac{\lambda}{4} \right) + \omega t \right] \]

(ii) \[ D(y,t) = 2A \sin \left[ k \sqrt{y^2 + \left( \frac{\lambda}{4} \right)^2} - \omega t \right] \].

(iii) Two. Explanation required.
(iv) Strong. (The centre point is an antinode of a standing wave.)
(v) Graph required. (It should show beats.)
6. 
(a) Diverging lenses. Justification required.

(b) 
(i) 393 nm.
(iii) Sketch required.
(iv) The image of the fish is closer to the actual position of the fish without the glass. (Note that in both cases the image is formed directly above the actual position of the fish. The glass produces both a vertical and horizontal displacement of the image compared to the image with no glass.)

(c) 
(i) Explanation required.
(ii) Hubble could not resolve 10 cm high characters. (The minimum resolvable angle for Hubble is $2.80 \times 10^{-7}$ radians, while 10 cm characters subtend an angle of $1.61 \times 10^{-7}$ radians at the distance of Hubble.)

(d) 
(i) $v = \sqrt{2gd}$. Fringe rate: $R = \frac{2v}{\lambda} = \frac{2\sqrt{2gd}}{\lambda}$.
(ii) $\frac{dR}{dg} = \frac{1}{\lambda} \sqrt{g} \cdot 

7. 
(a) 
(i) 0.973 (97.3%)
(ii) Earth frame: 97.3 light years. Rob’s frame: 22.4 light years.

(b) 
(i) $(x, t) = (500 \text{ m}, 6.67 \mu\text{s})$.
(ii) $(x', t') = (0, 6.44 \mu\text{s})$.

(c) $0.866c = 2.60 \times 10^8 \text{ m/s}$. 
