These are the answers to the various questions for end-of-term exam preparation. Take these with a grain of salt; sometimes I do a bad job of using my calculator.

1. Obviously you have to differentiate
   (a) $-5\frac{m}{s}\hat{x} + \pi\frac{m}{s}\hat{y}$ and speed is $\sqrt{5^2+\pi^2}\frac{m}{s}$
   (b) $-4\frac{m}{s^2}\hat{x}$, $8N$
   (c) take the dot product using components, and use relation between the dot product and the lengths of the vectors and the angle between them. 176 degrees
   (d) dot product of velocity and force: $-24\frac{J}{s}$
2. more kinematics:
   (a) integrate the velocity to get $2m\hat{x} - 18m\hat{y}$
   (b) differentiate and get $-6\frac{m}{s^2}\hat{y}$
   (c) $2.03J$
3. $\frac{k}{4}\left(x_2^4 - x_1^4\right)$
4. A lot of projectile motion:
   (a) 70.35m
   (b) 65.71m
   (c) 74.36m
   (d) 1.29s
   (e) about 8.2m
   (f) 900J
   (g) 739J
   (h) 161J
5. more projectile motion, you have to get t in terms of v, and substitute.
   (a) $16.1\frac{m}{s}$
   (b) $19.1\frac{m}{s}$
6. static friction - it's in equilibrium until it can't be held by friction: 26.6 degrees

7. More statics:
   (a) 23.6kg
   (b) right (positive x-direction)
   (c) 99N
8. Statics involving torque. We did the simple ladder in class, this is a more involved example. 19.8 degrees
9. 11.5 kg
10. a spring stretches and changes the force it exerts.
    (a) 0.49m
    (b) 12J
    (c) -24J
11. Remember, $\vec{F_{net}} = m\vec{a}$
    (a) 29.6N
    (b) 29.6N
    (c) 29.6N
    (d) 35.6N
    (e) 23.6N
12. Relate the tension in the rope to the accelerations of the masses. You get a pair of linear equations. Solve them.
    (a) $3.27\frac{m}{s}$
    (b) 26.2N
    (c) The tensions would be different (net torque on the wheel) and the acceleration would be slower (because the wheel would have kinetic energy)
13. Centripetal acceleration is provided by the net force.
    (a) $18.5\frac{m}{s}$
    (b) $13.4\frac{m}{s}$

(c) It would slide. The maximum acceleration that friction can provide in this case is μg, but that is already the magnitude of the component towards the center of the circle. The tangential component would mean that the acceleration's magnitude is bigger than what friction can provide.

14. Conservation of energy and circular motion

    (a) 0.75m above the top

    (b) ~~54~~N 65N

    (c) the ball would have more kinetic energy because of rolling. 1.06m above the top of loop, and ~~43~~N. 54N

15. Use the work energy theorem for this.

    (a) 9.18m

    (b) $\Delta\vec{p} = -4.3\frac{kg\ m}{s}\hat{x}$

    (c) 0.35m

    (d) 1.24m up, or 3.62m along slope.

16. Conservation of momentum

    (a) 254 degrees counterclockwise from positive x-axis

    (b) $1.77\frac{m}{s}$

    (c) -25.2 J (KE reduced)

    (d) $\Delta\vec{p} = -7\frac{kg\ m}{s}\hat{x} - 3.4\frac{kg\ m}{s}\hat{y}$ so $\vec{F} = -700N\hat{x} - 340N\hat{y}$

17. Momentum and energy both the same before and after:

    (a) $5.71\frac{m}{s}\hat{x}$

    (b) $-4.28\frac{m}{s}\hat{x}$

    (c) $28.6\frac{kg\ m}{s}\hat{x}$

    (d) $-8.6\frac{kg\ m}{s}\hat{x}$

18. rotational motion

    (a) 5 rad/s

    (b) 72J (rotating and moving)

    (c) $6\frac{m}{s}$

19. more rotational motion

    (a) $37.7\frac{rad}{s}$
    (b) $7.54\frac{m}{s}$

20. Newtonian gravity

    (a) $4.4 \times 10^4 s$
    (b) $2.83 \times 10^3 \frac{m}{s}$
    (c) $240N$
    (d) $2.4 \times 10^9 J$
    (e) $-4.8 \times 10^9 J$
    (f) $1.24 \times 10^5 s$

21. Electric force and electric potential energy.

    (a) $8.4 \times 10^4 \hat{x} + 9.6 \times 10^4 N\hat{y}$
    (b) $-3.7 \times 10^5 J$
    (c) $-1.7 \times 10^7 \frac{N}{C}\hat{x} - 1.9 \times 10^7 \frac{N}{C}\hat{y}$
    (d) $W_{done} = \Delta PE = 2.8 \times 10^5 J$

22. Conservation of energy

    (a) $18m$
    (b) $26.5\frac{m}{s}$
    (c) $\Delta PE = q\Delta V \rightarrow \Delta V = -2 \times 10^6 \frac{J}{C} = -2 \times 10^6 V$

23. Lorentz force and circular motion

    (a) $4.6 \times 10^{-3} m$
    (b) $4.6mm$ in the *negative* $\hat{y}$ direction from the initial position of the ion.

24. The ion will initially be moving along the electric field. When it hits the magnetic field it will experience a force perpendicular to motion, so it will turn.

    (a) Work-energy theorem: $6.1 \times 10^4 \frac{m}{s}$

(b) The initial force from the Lorentz force will be in the $\hat{z}$ direction. For a particle moving with velocity $6.1 \times 10^4 \frac{m}{s} \hat{z}$ in a region where $\vec{E} = 1000 \frac{V}{m} \hat{x}$, the magnetic field where there is no net force is $\vec{B} = 1.6 \times 10^{-2} T \hat{y}$.

25. Circuits:

    (a) 160Ω

    (b) see next

    (c) Resistors are labelled 1–5. 1: $I = 0.0625A$, $P = 0.39W$; 2: $I = 0.0375A$, $P = 0.14W$; 3: $I = 0.0250A$, $P = 0.063W$; 4 and 5: $I = 0.0125A$, $P = 0.016W$.

    (d) Point 'a' is $1.25V$ higher in potential than the negative pole of the battery.

26. More circuits; use Kirchoff's laws. Through the 100Ω, $0.0928A$ left; through 50Ω, $0.114A$ right; through 200Ω, $0.0214A$ left.